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Welcome to the course website for Computer Systems and Programming Tools in Fall2023 with Professor Brown.

This class meets TuTh 12:30-1:45 in library 166

This website will contain the syllabus, class notes, and other reference material for the class.

Navigating the Sections

The Syllabus section has logistical operations for the course broken down into sections. You can also read straight through by starting in the first one and navigating to the next section using the arrow navigation at the end of the page.

This site is a resource for the course. We do not follow a text book for this course, but all notes from class are posted in the notes section, accessible on the left hand side menu, visible on large screens and in the menu on mobile.

The resources section has links and short posts that provide more context and explanation. Content in this section is for the most part not strictly the material that you'll be graded on, but it is often material that will help you understand and grow as a programmer and data scientist.

Reading each page

Some pages of the syllabus and resources are also notebooks, if you want to see behind the curtain of how I manage the course information.

```
# this is a comment in a code block  
command argument --option -a
```

```
command output  
important line, emphasized
```

Try it Yourself

Notes will have exercises marked like this

Question from Class

Questions that are asked in class, but unanswered at that time will be answered in the notes and marked with a box like this. Long answers will be in the main notes

Further reading

Notes that are mostly links to background and context will be highlighted like this. These are optional, but will mostly help you understand code excerpts they relate to.

Hint

Both notes and assignment pages will have hints from time to time. Pay attention to these on the notes, they'll typically relate to things that will appear in the assignment.

Click here!

Special tips will be formatted like this

Check your Comprehension

Questions to use to check your comprehension will looklike this

Contribute

Chances to earn community badges will sometimes be marked like this

Computer Systems and Programming Tools

About this course

In this course we will study the tools that we use as programmers and use them as a lens to study the computer system itself. We will begin with two fundamental tools: version control and the shell. We will focus on git and bash as popular examples of each. Sometimes understanding the tools requires understanding an aspect of the system, for example git uses cryptographic hashing which requires understanding number systems. Other times the tools help us see how parts work: the shell is our interface to the operating system.

About this syllabus

This syllabus is a *living* document. You can get notification of changes from GitHub by "watching" the [repository](#). You can view the date of changes and exactly what changes were made on the Github [commit history](#) page.

Creating an [issue](#) is also a good way to ask questions about anything in the course it will prompt additions and expand the FAQ section.

Should you download the syllabus and rely on your offline copy?

No, because the syllabus changes

About your instructor

Name: Dr. Sarah M Brown Office hours: listed on communication page

Dr. Sarah M Brown is a third year Assistant Professor of Computer Science, who does research on how social context changes machine learning. Dr. Brown earned a PhD in Electrical Engineering from Northeastern University, completed a postdoctoral fellowship at University of California Berkeley, and worked as a postdoctoral research associate at Brown University before joining URI. At Brown University, Dr. Brown taught the Data and Society course for the Master's in Data Science Program. You can learn more about me at my [website](#) or my research on my [lab site](#).

You can call me Professor Brown or Dr. Brown, I use she/her pronouns.

The best way to contact me is e-mail or an issue on an assignment repo. For more details, see the [Communication Section](#)

Land Acknowledgement

Important

The University of Rhode Island land acknowledgment is a statement written by members of the University community in close partnership with members of the Narragansett Tribe. For more information see [the university land acknowledgement page](#)

The University of Rhode Island occupies the traditional stomping ground of the Narragansett Nation and the Niantic People. We honor and respect the enduring and continuing relationship between the Indigenous people and this land by teaching and learning more about their history and present-day communities, and by becoming stewards of the land we, too, inhabit.

Tools and Resources

We will use a variety of tools to conduct class and to facilitate your programming. You will need a computer with Linux, MacOS, or Windows. It is unlikely that a tablet will be able to do all of the things required in this course. A Chromebook may work, especially with developer tools turned on. Ask Dr. Brown if you need help getting access to an adequate computer.

All of the tools and resources below are either:

- paid for by URI **OR**
- freely available online.

BrightSpace

On BrightSpace, you will find links to other resource, this site and others. Any links that are for private discussion among those enrolled in the course will be available only from Brightspace.

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Prismia chat

Our class link for [Prismia chat](#) is available on Brightspace. Once you've joined once, you can use the link above or type the url: prismia.chat. We will use this for chatting and in-class understanding checks.

On Prismia, all students see the instructor's messages, but only the Instructor and TA see student responses.

Important

Prismia is **only** for use during class, we do not read messages there outside of class time

You can get a transcript from class from Prismia.chat using the menu in the top right.

Course Website

The course website will have content including the class policies, scheduling, class notes, assignment information, and additional resources.

Links to the course reference text and code documentation will also be included here in the assignments and class notes.

GitHub

You will need a [GitHub Account](#). If you do not already have one, please [create one](#) by the first day of class. If you have one, but have not used it recently, you may need to update your password and login credentials as the [Authentication rules](#) changed in Summer 2021.

You will also need the [gh CLI](#). It will help with authentication and allow you to work with other parts of github besides the core git operations.

Important

You need to install this on Mac

Programming Environment

In this course, we will use several programming environments. In order to participate in class and complete assignments you need the items listed in the requirements list. The easiest way to meet these requirements is to follow the recommendations below. I will provide instruction assuming that you have followed the recommendations. We will add tools throughout the semester, but the following will be enough to get started.

Warning

This is not technically a *programming* class, so you will not need to know how to write code from scratch in specific languages, but we will rely on programming environments to apply concepts.

Requirements:

- Python with scientific computing packages (numpy, scipy, jupyter, pandas, seaborn, sklearn)
- a C compiler
- Git
- A bash shell
- A web browser compatible with [Jupyter Notebooks](#)
- nano text editor (comes with GitBash and default on MacOS)
- one IDE with git support (default or via extension)
- the [GitHub CLI](#) on all OSs

Recommendation

[Windows- option A](#) [Windows - option B](#) [MacOS](#) [Linux](#) [Chrome OS](#)

- Install python via [Anaconda video install](#)
- Git and Bash with [GitBash](#) ([video instructions](#)).

Zoom

(backup only & office hours only)

This is where we will meet if for any reason we cannot be in person. You will find the link to class zoom sessions on Brightspace.

URI provides all faculty, staff, and students with a paid Zoom account. It can run in your browser or on a mobile device, but you will be able to participate in office hours and any online class sessions if needed best if you download the [Zoom client](#) on your computer. Please [log in](#) and [configure your account](#). Please add a photo (can be yourself or something you like) to your account so

[Skip to main content](#)

that we can still see your likeness in some form when your camera is off. You may also wish to use a virtual background and you are welcome to do so.

For help, you can access the [instructions provided by IT](#).

Grading

This section of the syllabus describes the principles and mechanics of the grading for the course. The course is designed around your learning so the grading is based on you demonstrating how much you have learned.

Additionally, since we will be studying programming tools, we will use them to administer the course. To give you a chance to get used to the tools there will be a grade free zone for the first few weeks.

Learning Outcomes

The goal is for you to learn and the grading is designed to as close as possible actually align to how much you have learned. So, the first thing to keep in mind, always is the course learning outcomes:

By the end of the semester, students will be able to:

1. Apply common design patterns and abstractions to understand new code bases, programming tools, and components of systems.
2. Apply appropriate programming workflows using context-relevant tools that enable adherence to best practices for effective code, developer time efficiency, and collaboration.
3. Differentiate the different classes of tools used in computer science in terms of their features, roles, and how they interact and justify positions and preferences among popular tools
4. Identify how information flows across levels of abstraction.
5. Discuss implications of design choices across levels of abstraction
6. Describe the social context in which essential components of computing systems were developed and explain the impact of that context on the systems.
7. Differentiate between social conventions and technical requirements in programming contexts.

These are what I will be looking for evidence of to say that you met those or not.

Principles of Grading

Learning happens through practice and feedback. My goal as a teacher is for you to learn. The grading in this course is designed to reflect how deeply you learn the material, even if it takes you multiple attempts to truly understand a topic. The topics in this course are all topics that will come back in later courses in the Computer Science major, so it is important that you understand each of them *correctly* so that it helps in the next course.

This course is designed to encourage you to work steadily at learning the material and demonstrating your new knowledge. There are no single points of failure, where you lose points that cannot be recovered. Also, you cannot cram anything one time and then forget it. The material will build and you have to demonstrate that you retained material. You will be required to demonstrate understanding of the connections between ideas from different parts of the course.

- Earning a C in this class means you have a general understanding; you will know what all the terms mean; you could follow along in a meeting where others were discussing systems concepts and use core tools for common tasks. You know where to start when looking things up.
- Earning a B means that you can apply the course concepts in other programming environments; you can solve basic common errors without looking much up.
- Earning an A means that you can use knowledge from this course to debug tricky scenarios; you can know where to start and can form good hypotheses about why uncommon errors have occurred; you can confidently figure out new complex systems.

The course is designed for you to *succeed* at a level of your choice. As you accumulate knowledge, the grading in this course is designed to be cumulative instead of based on deducting points and averaging. No matter what level of work you choose to engage in, you will be expected to revise work until it is correct. The material in this course will all come back in other 300 and 400 level CSC courses, so it is essential that you do not leave this course with misconceptions, as they will make it harder for you to learn related material later.

If you made an error in an assignment what do you need to do?

Read the suggestions and revise the work until it is correct.

Penalty-free Zone

Since learning developer tools is a core learning outcome of the course, we will also use them for all aspects of administering the course. This will help you learn these tools really well and create accountability for getting enough practice with core operations, but it also creates a high stakes situation: even submitting your work requires you understanding the tools. This would not be very fair at the beginning of the semester.

For the first three weeks we will have a low stakes penalty-free zone where we will provide extra help and reminders for how to get feedback on your work. In this period, deadlines are more flexible as well. If work is submitted incorrectly, we will still see it because we will manually go look for all activities. After this zone, we will assume you *chose* to skip something if we do not see it.

What happens if you merged a PR without feedback?

During the Penalty-Free zone, we will help you figure that out and fix it so you get credit for it. After that, you have to fix it on your own (or in office hours) in order to get credit.

Important

If there are terms in the rest of this section that do not make sense while we are in the penalty-free zone, do not panic. This zone exists to help you get familiar with the terms needed.

During the third week, you will create a course plan where you establish your goals for the course and I make sure that you all understand the requirements to complete your goals.

What happens if you're confused by the grading scheme right now?

Nothing to worry about, we will review it again in week three after you get a chance to build the right habits and learn vocabulary. We will also give you an activity that helps us to be sure that you understand it at that time.

Learning Badges

Your grade will be based on you choosing to work with the material at different levels and participating in the class community in different ways. Each of these represents different types of badges that you can earn as you accumulate evidence of your learning and engagement.

- experience: guided in class activities
- review: just the basics
- practice: a little bit more independent
- explore: posing your own directions of inquiry
- build: in depth- application of course topics

All of these badges will be tracked through PRs in your kwl repo. Each PR must have a title that includes the badge type and associated date. We will use scripts over these to track your progress.

To earn a D you must complete:

- 22 experience badges
- 13 lab check outs

To earn a C you must complete:

- 22 experience badges
- 13 lab check outs
- 18 review badges

To earn a B you must complete:

- 22 experience badges
- 13 lab check outs
- your choice:
 - 18 practice badges
 - 12 review + 12 practice

For an A you must complete:

- 22 experience badges
- 13 lab check outs
- your choice:
 - 18 practice badges + 6 explore badges
 - 18 review badges + 3 build badges
 - 6 review badges + 12 practice badges + 4 explore badges + 1 build badges
 - 12 review badges + 6 practice badges+ 2 explore badges + 2 build badges

You can also mix and match to get +/- . For example (all examples below assume 22+ experience badges and 13 lab checkouts)

- A-: 18 practice + 4 explore
- B+: 6 review + 12 practice + 4 explore

- B+: 24 practice
- C+: 12 review + 6 practice

Warning

These counts assume that the semester goes as planned and that there are 26 available badges of each base type (experience, review, practice). If the number of available badges decreases by more than 2 for any reason (eg snowdays, instructor illness, etc) the threshold for experience badges will be decreased.

Important

There will be 20 review and practice badges available after the penalty free zone. This means that missing the review and practice badges in the penalty free zone cannot hurt you. However, it does not mean it is a good idea to not attempt them, not attempting them at all will make future badges harder, because reviewing early ideas are important for later ideas.

You cannot earn both practice and review badges for the same class session, but most practice badge requirements will include the review requirements plus some extra steps.

In the second half of the semester, there will be special *integrative* badge opportunities that have multipliers attached to them. These badges will count for more than one. For example an integrative 2x review badge counts as two review badges. These badges will be more complex than regular badges and therefore count more.

Can you do any combination of badges?



No, you cannot earn practice and review for the same date.

Experience Badges

In class

You earn an experience badge in class by:

- preparing for class
- following along with the activity (creating files, using git, etc)
- responding to 80% of inclass questions (even incorrect or `:idk:`)
- reflecting on what you learned
- asking a question at the end of class

Makeup

You can make up an experience badge by:

- preparing for class
- reading the posted notes
- completing the activity from the notes

- attaching evidence as indicated in notes OR attending office hours to show the evidence

An experience report is evidence you have completed the activity and reflection questions. The exact form will vary per class, if you are unsure, reach out ASAP to get instructions. These are evaluated only for completeness/ good faith effort. Revisions will generally not be required, but clarification and additional activity steps may be advised if your evidence suggests you may have missed a step.

Do you earn badges for prepare for class?

No, prepare for class tasks are folded into your experience badges.

What do you do when you miss class?

Read the notes, follow along, and produce an experience report or attend office hours.

What if I have no questions?

Learning to ask questions is important. Your questions can be clarifying (eg because you misunderstood something) or show that you understand what we covered well enough to think of hypothetical scenarios or options or what might come next. Basically, focused curiosity.

Review and Practice Badges

The tasks for these badges will be defined at the bottom of the notes for each class session *and* aggregated to badge-type specific pages on the left hand side of the course website.

You can earn review and practice badges by:

- creating an issue for the badge you plan to work on
- completing the tasks
- submitting files to your KWL on a new branch
- creating a PR, linking the issue, and requesting a review
- revising the PR until it is approved
- merging the PR after it is approved

Where do you find assignments?

At the end of notes and on the separate pages in the activities section on the left hand side

You should create one PR per badge

The key difference between review and practice is the depth of the activity. Work submitted for review and practice badges will be assessed for correctness and completeness. Revisions will be common for these activities, because understanding correctly, without misconceptions, is important.

Important

Revisions are to help you improve your work **and** to get used to the process of making revisions. Even excellent work can be improved. The **process** of making revisions and taking good work to excellent or excellent to exceptional is a useful learning outcome. It will help you later to be really good at working through PR revisions; we will use the same process as code reviews in industry, even though most of it will not be code alone.

Explore Badges

Explore badges require you to pose a question of your own that extends the topic. For inspiration, see the practice tasks and the questions after class.

Details and more ideas are on the [explore](#) page.

You can earn an explore badge by:

- creating an issue proposing your idea (consider this ~15 min of work or less)
- adjusting your idea until given the proceed label
- completing your exploration
- submitting it as a PR
- making any requested changes
- merging the PR after approval

For these, ideas will almost always be approved, the proposal is to make sure you have the right scope (not too big or too small). Work submitted for explore badges will be assessed for depth beyond practice badges and correctness. Revisions will be more common on the first few as you get used to them, but typically decrease as you learn what to expect.

Important

Revisions are to help you improve your work **and** to get used to the process of making revisions. Even excellent work can be improved. The **process** of making revisions and taking good work to excellent or excellent to exceptional is a useful learning outcome. It will help you later to be really good at working through PR revisions; we will use the same process as code reviews in industry, even though most of it will not be code alone.

You should create one PR per badge

Build Badges

Build badges are for when you have an idea of something you want to do. There are also some ideas on the [build](#) page.

You can earn a build badge by:

- creating an issue proposing your idea and iterating until it is given the “proceed” label
- providing updates on your progress
- completing the build
- submitting a summary report as a PR linked to your proposal issue

- merging the PR after approval

You should create one PR per badge

For builds, since they're bigger, you will propose intermediate milestones. Advice for improving your work will be provided at the milestones and revisions of the complete build are uncommon. If you do not submit work for intermediate review, you may need to revise the complete build. The build proposal will be assessed for relevance to the course and depth. The work will be assessed for completeness in comparison to the proposal and correctness. The summary report will be assessed only for completeness, revisions will only be requested for skipped or incomplete sections.

Community Badges

Community badges are awarded for extra community participation. Both programming and learning are most effective in good healthy collaboration. Since being a good member of our class community helps you learn (and helps others learn better), some collaboration is required in other badges. Some dimensions of community participation can only be done once, for example fixing a typo on the course website, so while it's valuable, all students cannot contribute to the course community in the same way. To reward these unique contributions, you can earn a community badge.

You can see some ideas as they arise by [issues labeled `community`](#).

Community badges can replace missed experience, review, and practice badges, upgrade a review to a practice badge, or they can be used as an alternate way to earn a + modifier on a D,C, or B (URI doesn't award A+s, sorry). Community badges are smaller, so they are not 1:1 replacements for other badges. You can earn a maximum of 14 community badges, generally one per week. Extra helpful contributions may be awarded 2 community badges, but that does not increase your limit. When you earn them, you can plan how you will use it, but they will only be officially applied to your grade at the end of the semester. They will automatically be applied in the way that gives you the maximum benefit.

Community Badge values:

- 3 community = 1 experience badge
- 4 community = 1 review
- 7 community = 1 practice.
- 3 community badges + 1 review = 1 practice.
- 10 community = add a  to a D,C, or B, **note that this is more efficient.**

You can earn community badges by:

- fixing small issues on the course website (during penalty free zone only)
- contributing extra terms or reviews to your team repo
- sharing articles and discussing them in the course discussions
- contributing annotated resources to the course website

You will maintain a list of your contributions in your KWL repo in the [`community_contributions.md`](#) file. Every individual change to this file (representing one contribution) should be committed to a new branch and then submitted as a PR, with a review requested from @brownsarahm.

Note

Some participation in your group repo and a small number of discussions will be required for experience, review, and practice badges. This means that not every single contribution or peer review to your team repo will earn a community badge.

Example(nonexhaustive) uses:

- 22 experience + 17 review + 11 community = C (replace 2 experience, 1 review)
- 24 experience + 17 review + 5 community = C (replace 1 review)
- 24 experience + 18 review + 10 community = C+ (modifier)
- 24 experience + 18 practice + 10 community = B+ (modifier)
- 23 experience + 18 practice + 13 community = B+ (modifier, replace 1 experience)
- 24 experience + 16 practice + 2 review + 10 community = B (upgrade 2 review)
- 24 experience + 10 review + 10 community + 6 practice + 3 explore + 2 build = A (replace 2 review)
- 24 experience + 14 review + 10 community + 4 practice + 3 explore + 2 build = A (upgrade 2 review to practice)
- 24 experience + 12 review + 14 community + 4 practice + 3 build = A (replace 2 practice)

These show that community badges can save you work at the end of the semester by reducing the number of practice badges or simplifying badges

Free corrections

All work must be correct and complete to earn credit. In general, this means that when your work is not correct, we will give you guiding questions and advice so that you can revise the work to be correct. Most of the time asking you questions is the best way to help you learn, but sometimes, especially for small things, showing you a correct example is the best way to help you learn.

Additionally, on rare occasions, a student can submit work that is incorrect or will have down-the-line consequences but does not demonstrate a misunderstanding. For example, in an experience badge, putting text below the `#` line instead of replacing the hint within the `< >`. Later, we will do things within the kwl repo that will rely on the title line being filled in, but it's not a big revision where the student needs to rethink about what they submitted.

In these special occasions, good effort that is not technically correct may be rewarded with a . In this case, the instructor or TA will give a suggestion, with the  emoji in the comment and leave a review as "comment" instead of "changes requested" or "approved". If the student commits the suggestion to acknowledge that they read it, the instructor will then leave an approving review. Free corrections are only available when revisions are otherwise eligible. This means that they cannot extend a deadline and they are not available on the final grading that occurs after our scheduled "exam time".

Important

These free corrections are used at the instructional team's discretion and are not guaranteed.

This means that, for example, the same mistake the first time, might get a , a second will probably be a hint, and a third or fourth time might be a regular revision where we ask you to go review prior assignments to figure out what you need to fix with a broad hint instead of the specific suggestion

 Note

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IDEA



If the course response rate on the IDEA survey is about 75%,  will be applicable to final grading. **this includes the requirement of the student to reply**

Deadlines

There will be fixed feedback hours each week, if your work is submitted by the start of that time it will get feedback. If not, it will go to the next feedback hours.

We do not have a final exam, but URI assigns an exam time for every class. The date of that assigned exam will be the final due date for all work including all revisions.

Experience badges

Prepare for class tasks must be done before class so that you are prepared. Missing a prepare task could require you to do an experience report to make up what you were not able to do in class.

If you miss class, the experience report should be at least attempted/drafted (though you may not get feedback/confirmation) before the next class that you attend. This is strict, not as punishment, but to ensure that you are able to participate in the next class that you attend. Skipping the experience report for a missed class, may result in needing to do an experience report for the next class you attend to make up what you were not able to complete due to the missing class activities.

If you miss multiple classes, create a catch-up plan to get back on track by contacting Dr. Brown.

Review and Practice Badges

These badges have 5 stages:

- posted: tasks are on the course website
- planned: an issue is created
- started: one task is attempted and a draft PR is open
- completed: all tasks are attempted PR is ready for review, and a review is requested
- earned: PR is approved (by instructor or a TA) and work is merged

Tip

these badges *should* be started before the next class. This will set you up to make the most out of each class session. However, only prepare for class tasks have to be done immediately.

These badges badges must be *started* within one week of when they are posted (2pm) and *completed* within two weeks. A task is attempted when you have answered the questions or submitted evidence of doing an activity or asked a sincere clarifying question.

If a badge is planned, but not started within one week it will become expired and ineligible to be earned. You may request extensions to complete a badge by updating the PR message, these will typically be granted. Extensions for starting badges will only be granted in exceptional circumstances.

Expired badges will receive a comment and be closed

Once you have a good-faith attempt at a complete badge, you have until the end of the semester to finish the revisions in order to earn the badge.

💡 Tip

Try to complete revisions quickly, it will be easier for you

Explore Badges

Explore badges have 5 stages:

- proposed: issue created
- in progress: issue is labeled “proceed” by the instructor
- complete: work is complete, PR created, review requested
- revision: “request changes” review was given
- earned: PR approved

Explore badges are feedback-limited. You will not get feedback on subsequent explore badge proposals until you earn the first one. Once you have one earned, then you can have up to two in progress and two in revision at any given time.

Build Badges

You may earn at most one build badge per month, with final grading in December. To earn three build badges, you must earn the first one by the end of October.

Ungrading Option

At the end of the semester, you have the option of submitting a final reflection that states what grade you think you deserve, and justifies it by summarizing what you have learned and providing evidence of that. Instructions for this option will be provided as we approach the end of the semester. The policy of no submitted content that was not generated by you still applies. If you take this option, you may be required to also take an oral exam by appointment to supplement the evidence provided in your reflection.

This option exists in recognition of the fact that grading schemes are not perfect and I am truly committed to your learning. If you think that the grading scheme described on this page is working out to you earning a different grade than you deserve and you can support that with strong evidence that you have learned, you can have the grade you deserve.

🔔 What do you think?

share your thoughts on this option in the discussions for the class and then

Academic Honesty Violation Penalty

All of your work must reflect your own thinking and understanding. The work that you submit must all be your own work or content

[Skip to main content](#)

If you are found to submit prismia responses that do not reflect your own thinking or that of discussion with peers as directed, the experience badge for that class session will be ineligible.

If work is suspected, you will be allowed to take an oral exam in lab time to contest and prove that your work reflects your own understanding.

The first time you will be allowed to appeal through an oral exam. If your appeal is successful, your counter resets. If you are found to have violated the policy then no further work will be graded for the remainder of the semester

If you are found to submit work that is not your own for a review or prepare badge, the review and prepare badges for that date will be ineligible and the penalty free zone terms will no longer apply to the first six badges.

If you are found to submit work that is not your own for an explore or build badge, that badge will not be awarded and your maximum badges at the level possible will drop to 2/3 of the maximum possible.

Badge Deadlines and Procedures

This page includes more visual versions of the information on the badge page. You should read both, but this one is often more helpful, because some of the processes take a lot of words to explain and make more sense with a diagram for a lot of people.

```
%matplotlib inline
import os
from datetime import date, timedelta
import calendar
import pandas as pd
import numpy as np
import seaborn as sns
from myst_nb import glue
# style note: when I wrote this code, it was not all one cell. I merged the cells
# for display on the course website, since Python is not the main outcome of this course

# semester settings
first_day = date(2023, 9, 5)
last_day = date(2023, 12, 12)

no_class_ranges = [(date(2023, 11, 23), date(2023, 11, 26)),
                    (date(2023, 11, 13)),
                    (date(2023, 10, 10))]

meeting_days =[1,3] # datetime has 0=Monday
spring_break = (date(2023, 3, 11), date(2023, 3, 19))
penalty_free_end = date(2023, 9, 28)

def day_off(cur_date, skip_range_list):
    """
    is the current date a day off?

    Parameters
    -----
    cur_date : datetime.date
        date to check
    skip_range_list : list of datetime.date objects or 2-tuples of datetime.date
        dates where there is no class, either single dates or ranges specified by a tuple

    Returns
    -----
    day_is_off : bool
        True if the day is off, False if the day has class
    """

    # default to not a day off
    day_is_off=False
    #
    for skip_range in skip_range_list:
        if type(skip_range) == tuple:
            # if any of the conditions are true that increments and it will never go down, flase=0, true=1
            day_is_off += skip_range[0]<=cur_date<=skip_range[1]
        else:
            day_is_off += skip_range == cur_date
    #
    return day_is_off

# enumerate weeks
meeting_days =[1,3] # spring
mtg_delta = timedelta(meeting_days[1]-meeting_days[0])
week_delta = timedelta(7)

during_sb = lambda d: spring_break[0]<d<spring_break[1]

possible = [(first_day+week_delta*w, first_day+mtg_delta+week_delta*w) for w in range(weeks)]
weekly_meetings = [[c1,c2] for c1,c2 in possible if not(day_off(c1,no_class_ranges))]
meetings = [m for w in weekly_meetings for m in w]
meetings_string = [m.isoformat() for m in meetings]
weekly_meetings

# possible = [(first_day+week_delta*w, first_day+mtg_delta+week_delta*w) for w in range(weeks)]
# weekly_meetings = [[c1,c2] for c1,c2 in possible if not(during_sb(c1))]
meetings = [m for w in weekly_meetings for m in w if not(m in skins)]
```

[Skip to main content](#)

```

# build a table for the dates
badge_types = ['experience', 'review', 'practice']
target_cols = ['review_target','practice_target']
df_cols = badge_types + target_cols
badge_target_df = pd.DataFrame(index=meetings, data=[[['future'] * len(df_cols)] * len(meetings),
                                                       columns=df_cols].reset_index().rename(
                                                       columns={'index': 'date'}))

# set relative dates
today = date.today()
start_deadline = date.today() - timedelta(7)
complete_deadline = date.today() - timedelta(14)

# mark eligible experience badges
badge_target_df['experience'][badge_target_df['date'] <= today] = 'eligible'
# mark targets, cascading from most recent to oldest to not have to check < and >
badge_target_df['review_target'][badge_target_df['date'] <= today] = 'active'
badge_target_df['practice_target'][badge_target_df['date'] <= today] = 'active'
badge_target_df['review_target'][badge_target_df['date']
                                 <= start_deadline] = 'started'
badge_target_df['practice_target'][badge_target_df['date']
                                   <= start_deadline] = 'started'
badge_target_df['review_target'][badge_target_df['date']
                                 <= complete_deadline] = 'completed'
badge_target_df['practice_target'][badge_target_df['date']
                                   <= complete_deadline] = 'completed'

# mark enforced deadlines
badge_target_df['review'][badge_target_df['date'] <= today] = 'active'
badge_target_df['practice'][badge_target_df['date'] <= today] = 'active'
badge_target_df['review'][badge_target_df['date']
                         <= start_deadline] = 'started'
badge_target_df['practice'][badge_target_df['date']
                           <= start_deadline] = 'started'
badge_target_df['review'][badge_target_df['date']
                         <= complete_deadline] = 'completed'
badge_target_df['practice'][badge_target_df['date']
                           <= complete_deadline] = 'completed'
badge_target_df['review'][badge_target_df['date']
                         <= penalty_free_end] = 'penalty free'
badge_target_df['practice'][badge_target_df['date']
                           <= penalty_free_end] = 'penalty free'

# convert to numbers and set dates as index for heatmap compatibility
status_numbers_hm = {status:i+1 for i,status in enumerate(['future','eligible','active','penalty free','star
badge_target_df_hm = badge_target_df.replace(status_numbers_hm).set_index('date')

# set column names to shorter ones to fit better
badge_target_df_hm = badge_target_df_hm.rename(columns={'review':'review(e)', 'practice':'practice(e)',
                                                       'review_target':'review(t)', 'practice_target':'practi
# build a custom color bar
n_statuses = len(status_numbers_hm.keys())
manual_palette = [sns.color_palette("pastel", 10)[7],
                  sns.color_palette("colorblind", 10)[2],
                  sns.color_palette("muted", 10)[2],
                  sns.color_palette("colorblind", 10)[9],
                  sns.color_palette("colorblind", 10)[8],
                  sns.color_palette("colorblind", 10)[3]]

# generate the figure, with the colorbar and spacing
ax = sns.heatmap(badge_target_df_hm,cmap=manual_palette,linewidhts=1)
# move titles from bottom tot op
ax.xaxis.tick_top()
# pull the colorbar object for handling
colorbar = ax.collections[0].colorbar
# fix the location fo the labels on the colorbar
r = colorbar.vmax - colorbar.vmin
colorbar.set_ticks([colorbar.vmin + r / n_statuses * (0.5 + i) for i in range(n_statuses)])
colorbar.set_ticklabels(list(status_numbers_hm.keys()))
# add a title
today_string = today.isoformat()
glue('today',today_string,display=False)
glue('today_notdisplayed',"not today",display=False)
ax.set_title('Badge Status as of '+ today_string);

```

[Skip to main content](#)

```

-----
NameError                                                 Traceback (most recent call last)
Cell In[1], line 62
    58 week_delta = timedelta(7)
    59 during_sb = lambda d: spring_break[0]<d<spring_break[1]
--> 60 possible = [(first_day+week_delta*w, first_day+mtg_delta+week_delta*w) for w in range(weeks)]
    61 weekly_meetings = [[c1,c2] for c1,c2 in possible if not(day_off(c1,no_class_ranges))]
    62 meetings = [m for w in weekly_meetings for m in w]

NameError: name 'weeks' is not defined

```

Prepare work and Experience Badges Process

⚠ Warning

This was changed substantively on 2023-09-08

This is for a single example with specific dates, but it is similar for all future dates

The columns (and purple boxes) correspond to branches in your KWL repo and the yellow boxes are the things that you have to do. The “critical” box is what you have to wait for us on. The arrows represent PRs (or a local merge for the first one)

sequenceDiagram participant P as prepare Sep 12 participant E as experience Sep 12 participant M as main note over P:
complete prepare work
 between feb Sep 7 and Sep12 note over E: run experience badge workflow
 at the end of class
Sep12 P -> E: local merge or PR you that
 does not need approval note over E: fill in experience reflection critical Badge
review by instructor or TA E -> M: Experience badge PR option if edits requested note over E: make requested edits option when
approved note over M: merge badge PR end

In the end the commit sequence for this will look like the following:

gitGraph commit commit checkout main branch prepare-2023-09-12 checkout prepare-2023-09-12 commit id:
"gitunderstanding.md" branch experience-2023-09-12 checkout experience-2023-09-12 commit id: "initexp" merge prepare-2023-
09-12 commit id: "fillinexp" commit id: "revisions" tag:"approved" checkout main merge experience-2023-09-12
Where the “approved” tag represents and approving review on the PR.

Review and Practice Badge

Legend:

flowchart TD badgestatus[[Badge Status]] passive[/ something that has to occur
 not done by student /] student[Something for
you to do] style badgestatus fill:#2cf decisionnode{Decision/if} sta[action a] stb[action b] decisionnode --> |condition a|sta
decisionnode --> |condition b|stb subgraph phase[Phase] st[step in phase] end

This is the general process for review and practice badges

flowchart TD %% subgraph work[Steps to complete] subgraph posting[Dr Brown will post the Badge] direction TB write[/Dr Brown
finalizes tasks after class/] post[/Dr. Brown pushes to github/] link[/notes are posted with badge steps/] posted[[Posted: on badge
date]] write -->post post -->link post --o posted end subgraph planning[Plan the badge] direction TB create[/Dr Brown runs your
workflow/] decide{Do you need this badge?} close[close the issue] branch[create branch] planned[[Planned: on badge date]] create
-->decide decide -->|no| close decide -->|yes| branch create --o planned end subgraph work[Work on the badge] direction TB
start[do one task] commit[commit work to the branch] moretasks[complete the other tasks] ccommit[commit them to the branch]

[Skip to main content](#)

within two weeks
 of posted date]] wait[/wait for feedback/] start --> commit commit --> moretasks commit --o started
moretasks --> ccommit ccommit --> reqreview reqreview --> wait reqreview --o completed end subgraph review[Revise your
completed badges] direction TB prreview[Read review feedback] approvedq{what type of review} merge[Merge the PR]
edit[complete requested edits] earned[[Earned
 due by final grading]] discuss[reply to comments] prreview -->approvedq
approvedq -->|changes requested|edit edit -->|last date to edit: May 1| prreview approvedq -->|comment|discuss discuss --
>prreview approvedq -->|approved|merge merge --o earned end posting ==> planning planning ==> work work ==> review %%
styling style earned fill:#2cf style completed fill:#2cf style started fill:#2cf style posted fill:#2cf style planned fill:#2cf

Explore Badges

flowchart TD subgraph proposal[Propose the Topic and Product] issue[create an issue] proposed[[Proposed]]
reqproposalreview[Assign it to Dr. Brown] wait[/wait for feedback/] proceedcheck{Did Dr. Brown apply a proceed label?}
branch[start a branch] progress[[In Progress]] iterate[reply to comments and revise] issue --> reqproposalreview
reqproposalreview --> waitp reqproposalreview --> proposed waitp --> proceedcheck proceedcheck -->|no| iterate proceedcheck -->|yes| branch branch --> progress iterate -->waitp end subgraph work[Work on the badge] direction TB moretasks[complete the
work] ccommit[commit work to the branch] reqreview[request a review] wait[/wait for feedback/] complete[[Complete]] moretasks -->ccommit ccommit -->reqreview reqreview --o complete reqreview --> wait end subgraph review[Revise your work] direction TB
prreview[Read review feedback] approvedq{what type of review} revision[[In revision]] merge[Merge the PR] edit[complete
requested edits] earned[[Earned
 due by final grading]] prreview -->approvedq approvedq -->|changes requested|edit edit -->
prreview edit --o revision approvedq -->|approved| merge merge --o earned end proposal ==> work work ==> review %% styling
style proposed fill:#2cf style progress fill:#2cf style complete fill:#2cf style revision fill:#2cf style earned fill:#2cf

Build Badges

flowchart TD subgraph proposal[Propose the Topic and Product] issue[create an issue] proposed[[Proposed]]
reqproposalreview[Assign it] waitp[/wait for feedback/] proceedcheck{Did Dr. Brown apply a proceed label?} branch[start a branch]
progress[[In Progress]] iterate[reply to comments and revise] issue --> reqproposalreview reqproposalreview --> waitp
reqproposalreview --> proposed waitp --> proceedcheck proceedcheck -->|no| iterate proceedcheck -->|yes| branch branch -->
progress iterate -->waitp end subgraph work[Work on the badge] direction TB commit[commit work to the branch]
moretasks[complete the work] draftpr[Open a draft PR and
 request a review] ccommit[incorporate feedback]
reqreview[request a review] wait[/wait for feedback/] complete[[Complete]] commit -->moretasks commit -->draftpr draftpr -->ccommit
moretasks -->reqreview ccommit -->reqreview reqreview --> complete reqreview --> wait end subgraph review[Revise
your work] direction TB prreview[Read review feedback] approvedq{what type of review} revision[[In revision]] merge[Merge the
PR] edit[complete requested edits] earned[[Earned
 due by final grading]] prreview -->approvedq approvedq -->|changes
requested|edit edit --> prreview edit -->revision approvedq -->|approved| merge merge --o earned end proposal ==> work work ==>
review %% styling style proposed fill:#2cf style progress fill:#2cf style complete fill:#2cf style revision fill:#2cf style earned fill:#2cf

Community Badges

These are the instructions from your `community_contributions.md` file: For each one:

- In the `community_contributions.md` file on your kwl repo, add an item in a bulleted list (start the line with -)
- Include a link to your contribution like `[text to display](url/of/contribution)`
- create an individual pull request titled “Community-shortname” where `shortname` is a short name for what you did. approval on this PR by Dr. Brown will constitute credit for your grade

! Important

You want one contribution per PR for tracking

```
flowchart TD
    contribute[Make a contribution<br> *typically not in your KWL*] --> link[Add a link to your<br> contribution to your<br> communityt_contribution.md<br> in your KWL repo]
    link --> pr[Create a PR for that link]
    pr --> rev[Request a review<br> from @brownsarahm]
    rev --> approved[Dr. Brown approves]
    approved --> merge[Merge the PR]
    merge --o--> earned
```

Detailed Grade Calculations

! Important

This page is generated with code and calculations, you can view them for more precise implementations of what the english sentences mean.

► Show code cell source

Grade cutoffs for total influence are:

► Show code cell source

letter	threshold
D	44
D+	62
C-	80
C	98
C+	116
B-	134
B	152
B+	170
A-	188
A	206

The total influence of each badge is as follows:

► Show code cell source

	badge_type	badge	complexity	weight	influence
0	learning	experience	2.0	1.000000	2.000000
1	learning	review	3.0	1.000000	3.000000
2	learning	practice	6.0	1.000000	6.000000
3	learning	explore	9.0	1.000000	9.000000
4	learning	build	36.0	1.000000	36.000000
0	community	plus	1.0	1.800000	1.800000
1	community	experience_makeup	1.0	0.666667	0.666667
2	community	review_makeup	1.0	0.750000	0.750000
3	community	review_upgrade	1.0	1.000000	1.000000
4	community	practice_makeup	1.0	0.857143	0.857143

▶ Show code cell source

▶ Show code cell source

! Important

the labels on the horizontal axis are just example names, they do not have any meaning, I just have not figured out what I want to replace them with that might have meaning and need some sort of unique identifier there for the plot to work.

! Warning

Officially what is on the [Grading](#) page is what applies if this page is in conflict with that.

The total influence of a badge on your grade is the product of the badge's weight and its complexity. All learning badges have a weight of 1, but have varying complexity. All community badges have a complexity of 1, but the weight of a community badge can vary depending on what learning badges you earn.

There are also some hard thresholds on learning badges. You must have:

- 22 experience badges to earn a D or above
- at least 18 additional badges total across review and practice to earn above C or above

Only community badges can make exceptions to these thresholds. So if you are missing learning badges required to get to a threshold, your community badges will fill in for those. If you meet all of the thresholds, the community badges will be applied with more weight to give you a step up (eg C to C+ or B+ to A-).

Community badges have the most weight if you are on track for a grade between D and B+

If you are on track for an A, community badges can be used to fill in for learning badges, so for example, at the end of the semester, you might be able to skip some the low complexity learning badges (experience, review, practice) and focus on your high complexity ones to ensure you get an A.

More precisely the order of application for community badges:

- to make up missing experience badges
- to make up for missing review or practice badge to reach a total of 18 between these two types
- to upgrade review to practice to meet a threshold
- to give a step up (highest weight)

Schedule

Overview

The following is a tentative outline of topics in an order, these things will be filled into the concrete schedule above as we go. These are, in most cases bigger questions than we can tackle in one class, but will give the general idea of how the class will go.

How does this class work?

one week

We'll spend the first two classes introducing some basics of GitHub and setting expectations for how the course will work. This will include how you are expected to learn in this class which requires a bit about how knowledge production in computer science works and getting started with the programming tools.

What tools do Computer Scientists use?

Next we'll focus in on tools we use as computer scientists to do our work. We will use this as a way to motivate how different aspects of a computer work in greater detail. While studying the tools and how they work, we will get to see how some common abstractions are re-used throughout the fields and it gives a window and good motivation to begin considering how the computer actually works.

Topics:

- bash
- linux
- git
- i/o
- ssh and ssh keys
- number systems
- file systems

What Happens When I run code?

Finally, we'll go in really deep on the compilation and running of code. In this part, we will work from the compilation through to assembly down to hardware and then into machine representation of data.

Topics:

- software system and Abstraction
- programming languages
- cache and memory
- compilation
- linking
- basic hardware components

Tentative Schedule

This is the planned schedule, but is subject to change in order to adapt to how things go in class or additional questions that come up.

```
import pandas as pd
pd.read_csv('schedule.csv', index_col='date').sort_index()
```

	question	keyword	conceptual	practical	social	activity
date						
2023-09-07	Welcome, Introduction, and Setup	intro	what is a system, why study tools	GitHub basics	class intros	create kwl repo in github, navigate github.com...
2023-09-12	Course Logistics and Learning	logistics	github flow with issues	syllabus	working together and building common vocab	set up to work offline together, create a folder
2023-09-14	Bash intro & git offline	terminal start	git structure, paths and file system	bash path navigation, git terminal authentication	why developers work differently than casual users	navigate files and clone a repo locally
2023-09-19	How can I work with branches offline?	gitoffline	git branches	github flow offline, resolving merge conflicts	communication is important, git can help fix mi...	clone a repo and make a branch locally
2023-09-21	When do I get an advantage from git and bash?	why terminal	computing mental model, paths and file structure	bash navigation, tab completion	collaboration requires shared language, shared...	work with bash and recover from a mistake with...
2023-09-26	What *is* a commit?	merge conflicts	versions, git vlaues	merge conflicts in github, merge conflicts wit...	human and machine readable, commit messages ar...	examine commit objects, introduce plumbing com...
2023-09-28	How do programmers communicate about code?	documentation	build, automation, modularity, pattern matching,	generate documentation with jupyterbook, gitig...	main vs master, documentation community	make a jupyterbook
2023-10-03	What *is* git?	git structure	what is a file system, how does git keep track...	find in bash, seeing git config, plumbing/porc...	git workflows are conventions, git can be used...	examine git from multiple definitions and insp...
2023-10-05	Why are these tools like this?	unix philosophy	unix philosophy, debugging strategies	decision making for branches	social advantages of shared mental model, diff...	discussion with minor code examples
2023-10-12	How does git make a commit?	git internals	pointers, design and abstraction, intermediate...	inspecting git objects, when hashes are unique...	conventions vs requirements	create a commit using plumbing commands
2023-10-17	What is a commit number?	numbers	hashes, number systems	git commit numbers, manual hashing with git	number systems are derived in culture	discussion and use hashing algorithm
2023-10-19	How can can I release and share my code?	git references	pointers, git branches and tags	git branches, advanced fixing, semver and conv...	advantages of data that is both human and mach...	make a tag and release
2023-10-24	How can I automate things with bash?	bash scripting	bash is a programming language, official docs,...	script files, man pages, bash variables, bash ...	using automation to make collaboration easier	build a bash script that calculates a grade
2023-10-26	How can I work on a remote server?	server	server, hpc, large files	ssh, large files, bash head, grep, etc	hidden impacts of remote computation	log into a remote server and work with large f...

[Skip to main content](#)

date	question	keyword	conceptual	practical	social	activity
2023-10-31	What is an IDE?	IDE	IDE parts	compare and contrast IDEs	collaboration features, developer communities	discussions and sharing IDE tips
2023-11-02	How do I choose a Programming Language for a project?	programming languages	types of PLs, what is PL studying	choosing a language for a project	usability depends on prior experience	discussion or independent research
2023-11-07	How can I authenticate more securely from a terminal?	server use	ssh keys, hpc system structure	ssh keys, interactive, slurm	social aspects of passwords and security	configure and use ssh keys on a hpc
2023-11-09	What Happens when we build code?	building	building C code	ssh keys, gcc compiler	file extensions are for people, when vocabulary...	build code in C and examine intermediate outputs
2023-11-14	What happens when we run code?	hardware	von neuman architecture	reading a basic assembly language	historical context of computer architectures	use a hardware simulator to see step by step output
2023-11-16	How does a computer represent non integer quantities?	floats	float representation	floats do not equal themselves	social processes around standard developments, ...	work with float representation through fractions
2023-11-21	How can we use logical operations?	bitwise operation	what is a bit, what is a register, how to break them down	how an ALU works	tech interviews look for obscure details sometimes	derive addition from basic logic operations
2023-11-28	What *is* a computer?	architecture	physical gates, history	interpreting specs	social context influences technology	discussion
2023-11-30	How does timing work in a computer?	timing	timing, control unit, threading	threaded program with a race condition	different times matter in different cases	write a threaded program and fix a race condition
2023-12-05	How do different types of storage work together?	memory	different type of memory, different abstractions	working with large data	privacy/respect for data	large data that has to be read in batches
2023-12-07	How does this all work together	review	all	end of semester logistics	group work final	review quiz, integration/reflection questions
2023-12-12	How did this semester go?	feedback	all	grading	how to learn better together	discussion

Tentative Lab schedule

```
pd.read_csv('labschedule.csv', index_col='date').sort_index()
```

date	topic	activity
2023-09-08	GitHub Basics	syllabus quiz, setup
2023-09-15	working at the terminal	organization, setup kwl locally, manage issues
2023-09-22	offline branches	plan for success, clean a messy repo
2023-09-29	tool familiarity	work on badges, self progress report
2023-10-06	unix philosophy	design a command line tool that would enable a...
2023-10-13	git plumbing	git plumbing experiment
2023-10-20	git plumbing	grade calculation script, self reflection
2023-10-27	scripting	releases and packaging
2023-11-03	remote, hpc	server work, batch scripts
2023-11-10	Compiling	C compiling experiments
2023-11-17	Machine representation	bits and floats and number libraries
2023-12-01	hardware	self-reflection, work, project consultations
2023-12-08	os	hardware simulation

Support

Academic Enhancement Center

Academic Enhancement Center (for undergraduate courses): Located in Roosevelt Hall, the AEC offers free face-to-face and web-based services to undergraduate students seeking academic support. Peer tutoring is available for STEM-related courses by appointment online and in-person. The Writing Center offers peer tutoring focused on supporting undergraduate writers at any stage of a writing assignment. The UCS160 course and academic skills consultations offer students strategies and activities aimed at improving their studying and test-taking skills. Complete details about each of these programs, up-to-date schedules, contact information and self-service study resources are all available on the [AEC website](#).

- **STEM Tutoring** helps students navigate 100 and 200 level math, chemistry, physics, biology, and other select STEM courses. The STEM Tutoring program offers free online and limited in-person peer-tutoring this fall. Undergraduates in introductory STEM courses have a variety of small group times to choose from and can select occasional or weekly appointments. Appointments and locations will be visible in the TutorTrac system on September 14th, FIXME. The TutorTrac application is available through [URI Microsoft 365 single sign-on](#) and by visiting [aec.uri.edu](#). More detailed information and instructions can be found on the [AEC tutoring page](#).
- **Academic Skills Development** resources helps students plan work, manage time, and study more effectively. In Fall FIXME, all Academic Skills and Strategies programming are offered both online and in-person. UCS160: Success in Higher Education is a one-credit course on developing a more effective approach to studying. Academic Consultations are 30-minute, 1 to 1 appointments that students can schedule on Starfish with Dr. David Hayes to address individual academic issues. Study Your Way to Success is a self-guided web portal connecting students to tips and strategies on studying and time management related topics. For more information on these programs, visit the [Academic Skills Page](#) or contact Dr. Hayes directly at davidhayes@uri.edu.

* The Undergraduate Writing Center provides free writing support to students in any class, at any stage of the writing process.

are offered through two online options: 1) real-time synchronous appointments with a peer consultant (25- and 50-minute slots, available Sunday - Friday), and 2) written asynchronous consultations with a 24-hour turn-around response time (available Monday - Friday). Synchronous appointments are video-based, with audio, chat, document-sharing, and live captioning capabilities, to meet a range of accessibility needs. View the synchronous and asynchronous schedules and book online, visit uri.mywconline.com.

General URI Policies

Anti-Bias Statement:

We respect the rights and dignity of each individual and group. We reject prejudice and intolerance, and we work to understand differences. We believe that equity and inclusion are critical components for campus community members to thrive. If you are a target or a witness of a bias incident, you are encouraged to submit a report to the URI Bias Response Team at www.uri.edu/brt. There you will also find people and resources to help.

Disability, Access, and Inclusion Services for Students Statement

Your access in this course is important. Please send me your Disability, Access, and Inclusion (DAI) accommodation letter early in the semester so that we have adequate time to discuss and arrange your approved academic accommodations. If you have not yet established services through DAI, please contact them to engage in a confidential conversation about the process for requesting reasonable accommodations in the classroom. DAI can be reached by calling: 401-874-2098, visiting: web.uri.edu/disability, or emailing: dai@etal.uri.edu. We are available to meet with students enrolled in Kingston as well as Providence courses.

Academic Honesty

Students are expected to be honest in all academic work. A student's name on any written work, quiz or exam shall be regarded as assurance that the work is the result of the student's own independent thought and study. Work should be stated in the student's own words, properly attributed to its source. Students have an obligation to know how to quote, paraphrase, summarize, cite and reference the work of others with integrity. The following are examples of academic dishonesty.

- Using material, directly or paraphrasing, from published sources (print or electronic) without appropriate citation
- Claiming disproportionate credit for work not done independently
- Unauthorized possession or access to exams
- Unauthorized communication during exams
- Unauthorized use of another's work or preparing work for another student
- Taking an exam for another student
- Altering or attempting to alter grades
- The use of notes or electronic devices to gain an unauthorized advantage during exams
- Fabricating or falsifying facts, data or references
- Facilitating or aiding another's academic dishonesty
- Submitting the same paper for more than one course without prior approval from the instructors

The University is committed to delivering its educational mission while protecting the health and safety of our community. Students who are experiencing symptoms of viral illness should NOT go to class/work. Those who test positive for COVID-19 should follow the isolation guidelines from the Rhode Island Department of Health and CDC.

If you miss class, you do not need to notify me in advance. You can follow the makeup procedures

Excused Absences

Absences due to serious illness or traumatic loss, religious observances, or participation in a university sanctioned event are considered excused absences. For this, contact Dr. Brown when you are ready to get caught up and she will help you make a plan for the best order to complete missed work so that you are able to participate in subsequent activities. Extensions on badges will be provided if needed.

Mental Health and Wellness:

We understand that college comes with challenges and stress associated with your courses, job/family responsibilities and personal life. URI offers students a range of services to support your [mental health and wellbeing](#), including the [URI Counseling Center](#), [MySSP](#) (Student Support Program) App, the [Wellness Resource Center](#), and [Well-being Coaching](#).

Office Hours & Communication

⚠ Warning

Due to Indigenous People's Day:

- Amoy's Tuesday office hours on 10/10 are cancelled
- Dr. Brown's Monday office hours for 10/9 are moved to Tues 10/10

Announcements

Announcements will be made via GitHub Release. You can view them online in the releases page or you can get notifications by watching the repository, choosing "Releases" under custom see [GitHub docs](#) for instructions with screenshots. You can choose GitHub only or e-mail notification from the [notification settings page](#)

⚠ Warning

For the first few classes they will be made by BrightSpace too, but that will stop

🔔 Sign up to watch

Watch the repo and then create a file called [community.md](#) in your kwl repo and add a link to this section, like:

- [watched the repo as per announcements](<https://introcompsys.github.io/spring2023/syllabus/community.md>)

put this on a branch called [watch_community_badge](#) and title your PR "Community-Watch"

[Skip to main content](#)

Help Hours

Day	Time	Location	Host
Monday	11-1	Zoom	Marcin
Monday	4-5	Zoom	Dr. Brown
Tuesday	11:15-12:30	Tyler 140	Amoy
Wednesday	1-2	Zoom	Marcin
Thursday	11:15-12:30	Tyler 140	Amoy
Friday	10-11	Zoom	Marcin
Friday	3:45-5	Tyler 140	Amoy
Friday	4-5	Tyler 134	Dr. Brown (most weeks)

Online office hours locations are linked on the GitHub Organization Page

Important

You can only see them if you are a “member” to join, use the “Whole Class Discussion” link in prismia.

Tips

For assignment help

- **send in advance, leave time for a response** I check e-mail/github a small number of times per day, during work hours, almost exclusively. You might see me post to this site, post to BrightSpace, or comment on your assignments outside of my normal working hours, but I will not reliably see emails that arrive during those hours. This means that it is important to start assignments early.

Using issues

- use issues for content directly related to assignments. If you push your code to the repository and then open an issue, I can see your code and your question at the same time and download it to run it if I need to debug it
- use issues for questions about this syllabus or class notes. At the top right there's a GitHub logo ☒ that allows you to open a issue (for a question) or suggest an edit (eg if you think there's a typo or you find an additional helpful resource related to something)



...

You can submit a pull request for the typo above, but be sure to check the pull request tab of the repo before submitting to see if it has already been submitted.

For E-mail

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- Please include **[CSC392]** in the subject line of your email along with the topic of your message. This is important, because your messages are important, but I also get a lot of e-mail. Consider these a cheat code to my inbox: I have setup a filter that will flag your e-mail if you include that in subject to ensure that I see it.

🔔 Should you e-mail your work?

No, request a pull request review or make an issue if you are stuck

1. Welcome, Introduction, and Setup

1.1. Introductions

- Dr. Sarah Brown
- Please address me as Dr. Brown or Professor Brown,

You can see more about me in the about section of the syllabus.

I look forward to getting to know you all better.

1.2. Prismia

- instead of slides
- you can message us
- we can see all of your responses
- emoji!

questions can be “graded”

- this is instant feedback
- participation will be checked, not impact your final grade
- this helps both me and you know how you are doing

1.2.1. Some Background

- What programming environments do you have?
- What programming environments are you most comfortable with?
- what programming tools are you familiar with?

This information will help me prepare

1.3. This course will be different

- no Brightspace
- 300 level = more independence

- High expectations, with a lot of flexibility to work in a way that works for you

1.3.1. My focus is for you to learn

- that means, practice, feedback, and reflection
- you should know that you have learned
- you should be able to apply this material in other courses

1.3.2. Learning comes in many forms

- different types of material are best remembered in different ways
- some things are hard to explain, but watching it is very concrete

1.4. Learning is the goal

- producing outputs as fast as possible is not learning
- in a job, you may get paid to do things fast
- your work also needs to be correct, without someone telling you it is
- in a job you are trusted to know your work is correct, your boss does not check your work or grade you
- to get a job, you have to interview, which means explaining, in words, to another person how to do something

1.5. What about AI?

Large Language Models will change what programming looks like, but understanding is always going to be more effective than asking an AI. Large language models actually do not know anything, they just know what languages look like and generate text.

if you cannot tell it when it's wrong, you can not add value for a company

learning deeply means you can actually use them effectively and add value beyond an AI

1.6. This is a college course

- more than getting you one job, a bootcamp gets you one job
- build a long (or maybe short, but fruitful) career
- build critical thinking skill that makes you adaptable
- have options

1.7. “I never use what I learned in college”

- very common saying
- it's actually a sign of deep learning
- when we have expertise, we do not even notice when we apply it

Note

We may not think that we use the fact that we know the order of letters in the English language very often. Most of us learned the alphabet with a song, but we do not sing that on a daily basis.

However, we do fill out forms where we have to, for example, find the state we live in, in a dropdown and knowing the alphabetical order of the states helps us find ours faster.

When you know things really well, you apply them without noticing.

1.8. How does this work?

1.8.1. In class:

1. Memory/ understanding check
2. Review/ clarification as needed
3. New topic demo with follow along, tiny practice
4. Review, submit questions

1.8.2. Outside of class:

1. Build your cookbook with your team
2. Read notes Notes to refresh the material, check your understanding, and find more details
3. Practice material that has been taught
4. Activate your memory of related things to what we will cover
5. Read articles/ watch videos to either fill in gaps or learn more details
6. Bring questions to class

1.9. Getting started

Your KWL chart is where you will start by tracking what you know now/before we start and what you want to learn about each topic. Then you will update it throughout the semester. You will also add material to the repository to produce evidence of your learning.

Accept the assignment to create your repo

1. click on .github, then workflows, then track.yml
2. click the 3 dots menu and select delete
3. commit directly to main with the default message
4. back to the main code tab
5. Click the pencil to edit the readme
6. Add your name
7. Add a descriptive commit message
8. Choose create a branch and open a pull request

10. Click on the list of commits, now you have one more!

1.10. What is this course about?

In your KWL chart, there are a lot of different topics that are not obviously related, so what is this course really about?

- practical exposure to important tools
- design features of those tool categories
- basic knowledge of many parts of the CS core
- focus on the connections

We will use learning the tools to understand how computer scientists think and work.

Then we will use the tools to examine the field of Computer Science top to bottom (possibly out of order).

1.10.1. How it fits into your CS degree

1.11. In your degree

In CSC110, you learn to program in python and see algorithms from a variety of domain areas where computer science is applied.

Then in CSC 340 and 440 you study the algorithms more mathematically, their complexity, etc.

In CSC211, 212, you learn the foundations of computer science: general programming and data structures.

Then in 301, 305, 411, 412 you study different aspects of software design and how computers work.

In this class, we're going to connect different ideas. We are going to learn the tools used by computer scientists, deeply. You will understand why the tools are the way they are and how to use them even when things go wrong.

1.12. Git and GitHub terminology

We also discussed some of the terminology for git. We will also come back to these ideas in greater detail later.

1.12.1. Programming is Collaborative

There are two very common types of collaboration

- code review (working independently and then reviewing)
- pair programming (sitting together and discussing while writing)

We are going to build your skill in the *code review* model. This means you need to collaborate, but collaboration in school tends to be more stressful than it needs to. If students have different goals or motivation levels it can create conflict. So **you will have no group graded work** but you will get the chance to work on something together in a low stakes way.

You will have a "home team" that you work with throughout the semester to build a glossary and a "cookbook" of systems recipes.

💡 Tip
know
where
under

🔔 Fur
GitHub
have

-
-

Your contributions and your **peer reviews** will be assessed individually for your grade, but you need a team to be able to practice these collaborative aspects.

! **Important**

Remember to fill out the [team formation survey](#)

1.12.2. Class forum

This community repository “assignment” will add you to a “team” with the whole class. It allows us to share things on GitHub, for the whole class, but not the whole internet.

! **Important**

When you click that link join the existing team, do not make a new one

1.12.3. Get Credit for Today’s class

1. Run your Experience Reflection (inclass) action on your kwl repo
2. Complete the file.

1.13. Prepare for next class/lab

1. review notes after they are posted, both rendered and the raw markdown include links to each in your badge PR
2. map out your computing knowledge and add it to your kwl chart repo. this can be an image that you upload or a text-based outline in a file called prior-knowledge-map. (optional) try mapping out using [mermaid](#) syntax, we'll be using other tools that will facilitate rendering later

1.14. Review

1. Review the notes after I post them.
2. Fill in the first two columns of your KWL chart (on a branch for this badge).
3. [review git and github vocabulary](#) (include link in your badge PR)
4. Post an introduction to your classmates [on our discussion forum](#)

1.15. Practice

1. Review the notes after I post them.
2. Fill in the first two columns of your KWL chart (on a branch for this badge).
3. [review git and github vocabulary](#) be sure to edit a file and make an issue or PR (include link in your badge PR)
4. Post an introduction to your classmates [on our discussion forum](#)

2.1. What does it mean to study Computer Systems?

“Systems” in computing often refers to all the parts that help make the “more exciting” algorithmic parts work. Systems is like the magic that helps you get things done in practice, so that you can shift your attention elsewhere. In intro courses, we typically give you an environment to hide all the problems that could occur at the systems level.

Most of us have had a bug, where we found a solution to get by, without really understanding **why** the solution fixed it or why that bug happened.

Debugging often requires understanding, in practice, of how the programming language works, how it translates that to hardware, and how the hardware works.

the first “bug” was an **actual** moth

These programmers had to know how to take apart the physical computer in order to find the insect.

our computers are a lot different, but we still need systems understanding to be efficient.

! Important

In this course, we will take the time to understand all of this stuff. This means that we will use a different set of strategies to study it than we normally see in computer science.

This is a 300 level course, so you are one step closer to being a *professional* instead of **only** a *student*.

This is still a college course, so we will be taking time to understand the theory and the *why* not only the *what* that a bootcamp or on the job training might provide.

However, instead of using a text book that is designed explicitly and primarily for a school context, we will use **primary sources**.

In our context, that means using three main types of sources:

- official reference docs
- direct research results
- first hand accounts by professional developers

Back to what a system is ...

From ACM Transactions on Computer Systems

ACM Transactions on Computer Systems (TOCS) presents research and development results on the design, specification, realization, behavior, and use of computer systems. The term “computer systems” is interpreted broadly and includes systems architectures, operating systems, distributed systems, and computer networks. Articles that appear in TOCS will tend either to present new techniques and concepts or to report on experiences and experiments with actual systems. Insights useful to system designers, builders, and users will be emphasized.

We are going to be studying aspects of computer systems, but to really understand them, we also have to think about why they are the way they are. We will therefore study in a broad way.

We will look at blogs, surveys of developers, and actually examine the systems themselves

[Skip to main content](#)

2.2. Mental Models and Learning

- When we know something well, it is easier to do, we can do it multiple ways,
- it is easy to explain to others and we can explain it multiple ways.
- we can do the task almost automatically and combine and create things in new ways.

This is true for all sorts of things.

⚠ Important

We will practice and reinforce things a lot

a mental model is how you think about a concept and your way of relating it.

Novices have sparse mental models, experts have connected mental models.

2.3. Why do we need this for computer systems?

2.3.1. Systems are designed by programmers

⚠ Warning

this section is a little different than what I said in class, but it is still important and related.

Computer Science is not a natural science like biology or physics where we try to understand some aspect of the world that we live in. Computer Science as a discipline, like algorithms, mostly derives from Math.

So, when we study computer science, while parts of it are limited by physics^[1], most of it is essentially an imaginary world that is made by people. Understanding how people think, both generally, and common patterns within the community of programmers^[2] understand how things work and why they are the way they are. The why can also make it easier to remember, or, it can help you know what things you can find alternatives for, or even where you might invent a whole new thing that is better in some way.

2.3.2. Context Matters

This context of how things were developed can influence how we understand it. We will also talk about the history of computing as we go through different topics in class so that we can build that context up.

2.3.3. Optimal is relative

The “best” way to do something is always relative to the context. “Best” is a vague term. It could be most computationally efficient theoretically, fastest to run on a particular type of hardware, or easiest for another programmer to read.

We will see how the best choice varies a lot as we investigate things at different levels of abstraction.

For finding and reading this section, add a link to the heading above [Systems are designed by programmers](#) to your

a review from Dr Brown (@brownsarahm)

this will count for one community badge!

2.4. Let's get organized

For class you should have a folder on your computer where you will keep all of your materials.

Open a terminal window. I am going to use `bash` commands

- if you are on mac, your default shell is `zsh` which is mostly the same as bash for casual use. you can switch to bash to make your output more like mine using the command `bash` if you want, but it is not required.
- if you are on windows, your **GitBash** terminal will be the least setup work to use `bash`
- if you have WSL (if you do not, no need to worry) you should be able to set your linux shell to `bash`

The first command we will use is `pwd` which stands for print working directory.

```
pwd
```

```
/Users/brownsarahm
```

this is called the **path** and specifically this is an **absolute path**

We can change into another directory with `cd` for change directory

```
cd Documents/
```

To see what changed, we use `pwd` again

```
pwd
```

```
/Users/brownsarahm/Documents
```

Note that the current path is the same as the old one plus the place we changed to.

I moved one step further into my `inclass` folder

```
cd inclass/
```

We can **mak** a new **directory** with `mkdir`

```
mkdir systems
```

What you want to have is a folder for class (mine is `systems`) in a place you can find it. (mine is in my `inclass` folder)

We can **view** what is in a **folder** with `ls` for **list**

[Skip to main content](#)

```
ls
```

I have a few other folders here

```
fa22          prog4dsfa23      sp23          systems
```

And again check the path

```
pwd
```

```
/Users/brownsarahm/Documents/inclass
```

then I can do into the new folder I just made

```
cd systems/
```

and look at the path one more time

```
pwd
```

```
/Users/brownsarahm/Documents/inclass/systems
```

We can change back to the home directory with `~`

```
cd ~
```

and confirm:

```
pwd
```

```
/Users/brownsarahm
```

just like before

Then we can use the `relative path`` of where we want to go:

```
cd Documents/inclass/systems/
```

`cd` with no path also works

```
cd
```

and we can use `pwd` to see where we end up

[Skip to main content](#)

```
pwd
```

```
/Users/brownsarahm
```

it's the home directory just like `~`

```
cd Documents/inclass/systems/
```

`..` stands for up one level,

```
cd ../
```

```
pwd
```

```
/Users/brownsarahm/Documents/inclass/
```

2.5. Prepare for Next Class

1. Find the glossary page for the course website, link it below. Review the terms for the next class: shell, terminal, bash, git, GitHub.
2. Check your kwl repo before class and see if you have received feedback, reply or merge accordingly.
3. Make sure you have a working environment, see the list in the syllabus, including `gh` CLI if you use mac`. Use the discussions to ask for help.
4. Sign up for [announcements](#)

2.6. Review today's class

1. review notes after they are posted, both rendered and the raw markdown include links to each in your badge PR
2. map out your computing knowledge and add it to your kwl chart repo. this can be an image that you upload or a text-based outline in a file called prior-knowledge-map. (optional) try mapping out using [mermaid](#) syntax, we'll be using other tools that will facilitate rendering later

2.7. More Practice

1. review notes after they are posted, both rendered and the raw markdown versions. Include links to both views in your badge PR comment.
2. read Chapter 1, "Decoding your confusion while coding" in [The Programmer's Brain](#) add a file called brain.md to your kwl repo that summarizes your thoughts on the chapter and how, if at all, it changes how you think about debugging and learning to program.
3. map out your computing knowledge and add it to your kwl chart repo in a file called prior-knowledge-map.md. Use [mermaid](#) syntax, to draw your map. GitHub can render it for you including while you work using the preview button.

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2.8. Experience Report Evidence

In office hours, show us that you have a folder to work in for class.

2.9. Questions After Today's Class

2.9.1. I wonder why Mac and Linux have built-in terminals but Windows, arguably the most popular OS, does not have a built-in terminal?

It does have a built in terminal, it just uses a Windows-only shell, `bash` is the most popular shell to learn, because it is used on unix and linux systems and those are most commonly used for **developers** and code **production** environments where you may only have remote, terminal only access.

2.9.2. No real questions, maybe curious about downloading github files using commands

that is what we will do Thursday

2.9.3. I've seen this type of material before so I would want to know about from other things I've seen would be how to interact with apps (google chrome) and stuff like that if that's even possible?

one step of the action that builds the course syllabus pdf launches chromium and prints the syllabus to a pdf.

2.9.4. Will we be piping things in the command line often, or are we mostly getting an introduction to the concept?

we will be working with the shell A LOT

2.9.5. I want to know more about what reverting does to github

In a few classes, we will get there!

2.9.6. Does making directories in a shell put them in the directory automatically?

it puts them where you say, nothing explicit, is an implicit relative path to your current working directory.

2.9.7. Are there any benefits to choosing either zsh or bash? Ease of use, compatibility, or anything else

`bash` is more standard `zsh` can do some things a little faster

Note

Learning more about the differences is an option for an explore badge

2.9.8. why does cd and cd~ do the same thing?

 is a shortcut for home and so is nothing.

2.9.9. I want to know more about how git is connected and will be applied to github and other tools we use.

we will do this over the next few classes

2.9.10. how do I make up lectures

Read the notes and complete the experience report (makeup) action

2.9.11. Should I merge the add my name to readme pull request?

yes

2.9.12. if my lab was approved can i merge the pull request~

yes

2.9.13. in what cases does the terminal file explorer get used as opposed to just navigating the file explorer/finder?

Once you know the terminal, it becomes faster than the GUI. Also, if you need to programmatically move files, bash allows you to make scripts!

2.9.14. I think I'm still just a little confused on badges, and if they're basically this class's version of assignments, or something completely different.

they're roughly like assignments, it's how we track what work you have completed. Not *all* assigned badges are required though, no matter what grade you want to earn.

[1] when we are *really* close to the hardware

[2] Of course, not *all* programmers think the same way, but when people spend time together and communicate, they start to share patterns in how they think. So, while you do **not** have to think the same way as these patterns, knowing what they are will help you reading code, and understanding things.

3.1. Open a Terminal

Use the same one we used in the last class

and move to the folder we made to use as a working directory for in class

```
cd Documents/inclass/systems/
```

Note

we did some review, see the last notes instead of recapping that here

`..` is a special file that points to a specific relative path, of one level up.

we can use `cd` and `pwd` to illustrate what “one level up” means

```
pwd
```

```
/Users/brownsarahm/Documents/inclass/systems
```

```
cd ..
```

```
pwd
```

```
/Users/brownsarahm/Documents/inclass
```

we move to make the current working directory the one, one step prior in the hierarchy with `cd ..`

```
cd systems/
```

3.2. A toy repo for in class

Warning

I removed the link from the public notes, but you can get it in prismia

this repo will be for *in class* work, you will not get feedback inside of it, unless you ask, but you will answer questions in your kwl repo about what we do in this repo sometimes

only work in this repo during class time or making up class, unless specifically instructed to (will happen once in a few weeks)

3.3. Connecting with GitHub

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We have two choices to Download a repository:

1. clone to maintain a link using git
2. download zip to not have to use git, but have no link

we want option 1 because we are learning git

3.3.1. Authenticating with GitHub

There are many ways to authenticate securely with GitHub and other git clients. We're going to use *easier* ones for today, but we'll come back to the third, which is a bit more secure and is a more general type of authentication.

1. ssh keys (we will do this later)
2.  CLI / gitscm in GitBash through browser

3.3.2. Windows (gitbash)

- `git clone` and paste your URL from GitHub
- then follow the prompts, choosing to authenticate in Browser.

3.3.3. MacOS X

- GitHub CLI: enter `gh auth login` and follow the prompts.
- then `git clone` and paste your URL from github

3.3.4. If nothing else works

Create a [personal access token](#). This is a special one time password that you can use like a password, but it is limited in scope and will expire (as long as you choose settings well).

Then proceed to the clone step. You may need to configure an identity later with `git config`

3.3.5. Cloning a repo

```
git clone https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
```

then we get several messages back from git and GitHub (the remote)

```
Cloning into 'github-inclass-fa23-brownsarahm'...
remote: Enumerating objects: 8, done.
remote: Counting objects: 100% (8/8), done.
remote: Compressing objects: 100% (5/5), done.
remote: Total 8 (delta 0), reused 4 (delta 0), pack-reused 0
Receiving objects: 100% (8/8), done.
```

Confirm it worked with:

[Skip to main content](#)

```
ls
```

```
github-inclass-fa23-brownsarahm
```

We see the new folder that matches our repo name

3.4. What is in a repo?

We can enter that folder

```
cd github-inclass-fa23-brownsarahm/
```

When we compare the local directory to GitHub

```
ls
```

```
README.md
```

Notice that the `.github/workflows` that we see on GitHub is missing, that is because it is *hidden*. All file names that start with `.` are hidden.

We can actually see the rest with the `-a` for **all option or flag**. Options are how we can pass non required parameters to command line programs.

```
ls -a
```

```
.          .git      README.md  
..         .github
```

We also see some special “files”, `.` the current location and `..` up one directory

3.5. How do I know what git knows?

`git status` is your friend.

Let's see how it works:

```
git status
```

```
git: 'status' is not a git command. See 'git --help'.
```

```
The most similar command is  
status
```

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

nothing to commit, working tree clean
```

this command compares your working directory (what you can see with `ls -a` and all subfolders except the `.git` directory) to the current state of your `.git` directory.

this tells us:

- the branch we are on (`On branch main`)
- that we have incorporated all changes downloaded from GitHub (`up to date with 'origin/main'`)
- that our working directory matches what it was after the repo's last commit (`nothing to commit, working tree clean`)

3.6. Making a branch with GitHub.

Note

Run the one action in the github in class repo one time to get the issues

First on an issue, create a branch using the link in the development section of the right side panel. See the [github docs](#) for how to do that.

Then it gives you two steps to do. We are going to do them one at a time so we can see better what they each do.

```
git fetch origin
```

```
fatal: 'orign' does not appear to be a git repository
fatal: Could not read from remote repository.
```

```
Please make sure you have the correct access rights
and the repository exists.
```

Since the argument after `git fetch` is the variable name of a remote, when I spelled `origin` wrong, it says that it can't find it.

First we will update the `.git` directory without changing the working directory using `git fetch`. We have to tell git fetch where to get the data from, we do that using a name of a remote.

```
git fetch origin
```

```
From https://github.com/introcompsys/github-inclass-fa23-brownsarahm
 * [new branch]      1-create-an-about-file -> origin/1-create-an-about-file
```

then we check status again

[Skip to main content](#)

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

nothing to commit, working tree clean
```

Looks like nothing so far.

Next, we switch to that branch.

```
git checkout 1-create-an-about-file
```

```
branch '1-create-an-about-file' set up to track 'origin/1-create-an-about-file'.
Switched to a new branch '1-create-an-about-file'
```

and verify what happened

```
git status
```

```
On branch 1-create-an-about-file
Your branch is up to date with 'origin/1-create-an-about-file'.

nothing to commit, working tree clean
```

3.7. Creating a file on the terminal

The `touch` command creates an empty file.

```
touch about.md
```

We can use `ls` to see our working directory now.

```
ls
```

```
README.md      about.md
```

```
git status
```

```
On branch 1-create-an-about-file
Your branch is up to date with 'origin/1-create-an-about-file'.

Untracked files:
  (use "git add <file>..." to include in what will be committed)
    about.md
```

Now we see something new. Git tells us that there is a file in the working directory that it has not been told to track the changes in and it knows nothing.

It also tells us what we can do next. Under “Untracked files” it gives us advice for how to handle those files specifically. If we had made more than one type of change, there would be multiple subheadings each with their own suggestions.

The very last line is advice of what do to overall.

We're going to do a bit more work first though, by adding content to the file.

We are going to use the `nano` text editor to edit the file

```
nano about.md
```

On the nano editor the `^A` stands for control.

and we can look at the contents of it.

```
cat about.md
```

```
Sarah Brown  
2027
```

Now we will check again

```
git status
```

```
On branch 1-create-an-about-file  
Your branch is up to date with 'origin/1-create-an-about-file'.  
  
Untracked files:  
  (use "git add <file>..." to include in what will be committed)  
    about.md  
  
nothing added to commit but untracked files present (use "git add" to track)
```

In this case both say to `git add` to track or to include in what will be committed. Under untracked files it says `git add <file>...`, in our case this would look like `git add about.md`. However, remember we learned that the `.` that is always in every directory is a special “file” that points to the current directory, so we can use that to add all files. Since we have only one, the two are equivalent, and the `.` is a common shortcut, because most of the time we want to add everything we have recently worked on in a single commit.

`git add` puts a file in the “staging area” we can use the staging area to group files together and put changes to multiple files in a single commit. This is something we **cannot** do on GitHub in the browser, in order to save changes at all, we have to commit. Offline, we can save changes to our computer without committing at all, and we can group many changes into a single commit.

```
git add .
```

We will use status to see what has changed.

```
git status
```

```
On branch 1-create-an-about-file
Your branch is up to date with 'origin/1-create-an-about-file'.

Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
    new file:   about.md
```

Now that one file is marked as a new file and it is in the group “to be committed”. Git also tells us how to undo the thing we just did.

💡 Try this yourself

Try making a change, adding it, then restoring it. Use git status to see what happens at each point

Next, we will commit the file. We use `git commit` for this. the `-m` option allows us to put our commit message directly on the line when we commit. Notice that unlike committing on GitHub, we do not choose our branch with the `git commit` command. We have to be “on” that branch before the `git commit`.

```
git commit -m 'create and complete about file closes #1'
```

```
[1-create-an-about-file 693a2b5] create and complete about file closes #1
 1 file changed, 2 insertions(+)
 create mode 100644 about.md
```

⚠️ Warning

At this point you might get an error or warning about your identity. Follow what git says to either set or update your identity using `git config`

```
ls
```

```
README.md      about.md
```

Remember, the messages that git gives you are designed to try to help you. The developers of git know it's a complex and powerful tool and that it's hard to remember every little bit.

We again check in with git:

```
git status
```

```
On branch 1-create-an-about-file
Your branch is ahead of 'origin/1-create-an-about-file' by 1 commit.
  (use "git push" to publish your local commits)

nothing to commit, working tree clean
```

[Skip to main content](#)

Now it tells us we have changes that GitHub does not know about.

We can send them to github with `git push`

```
git push
```

```
Enumerating objects: 4, done.  
Counting objects: 100% (4/4), done.  
Delta compression using up to 8 threads  
Compressing objects: 100% (2/2), done.  
Writing objects: 100% (3/3), 347 bytes | 347.00 KiB/s, done.  
Total 3 (delta 0), reused 0 (delta 0), pack-reused 0  
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git  
 6a12db0..693a2b5 1-create-an-about-file -> 1-create-an-about-file
```

This tells us the steps git took to send:

- counts up what is there
- compresses them
- sends them to GitHub
- moves the `2-create-an-about-file` branch on GitHub from commit `3f54148` to commit `57de0cd`
- links the local `2-create-an-about-file` branch to the GitHub `2-create-an-about-file` branch

3.8. Review today's class

Any steps in a badge marked **lab** are steps that we are going to focus in on during lab time. Remember the goal of lab is to help you complete the work, not add additional work. The lab checkout will include some other tasks and then we will encourage you to work on this badge while we are there to help. Lab checkouts are checked only for completion though, not correctness, so steps of activities that we want you to really think about and revise if incorrect will be in a practice or review badge.

1. Read the notes. If you have any questions, post an issue on the course website repo.
2. Using your terminal, download your KWL repo. Include the command used in your badge PR.
3. Try using setting up git using your favorite IDE or GitHub Desktop. Make a file `gitoffline.md` and include some notes of how it went. Was it hard? easy? what did you figure out or get stuck on? Is the terminology consistent or does it use different terms?
4. **lab** Explore the difference between `git add` and `git commit`: try committing and pushing without adding, then add and push without committing. Describe what happens in each case in a file called `gitcommit.md`. Compare what happens based on what you can see on GitHub and what you can see with `git status`.

3.9. More Practice

Any steps in a badge marked **lab** are steps that we are going to focus in on during lab time. Remember the goal of lab is to help you complete the work, not add additional work. The lab checkout will include some other tasks and then we will encourage you to work on this badge while we are there to help. Lab checkouts are checked only for completion though, not correctness, so steps of activities that we want you to really think about and revise if incorrect will be in a practice or review badge.

1. Read the notes. If you have any questions, post an issue on the course website repo.
2. Using your terminal, download your KWL repo. Include the command used in your badge PR.

3. Try using setting up git using your favorite IDE or GitHub Desktop. Make a file `gitoffline.md` and include some notes of how it went. Was it hard? easy? what did you figure out or get stuck on? Is the terminology consistent or does it use different terms?
4. **lab** Explore the difference between `git add` and `git commit`: try committing and pushing without adding, then add and push without committing. Describe what happens in each case in a file called `gitcommit_tips.md`. Compare what happens based on what you can see on GitHub and what you can see with `git status`. Write a scenario with examples of how a person might make mistakes with `git add` and `git commit` and what to look for to get unstuck.

3.10. Prepare for Next Class

1. Reply below with any questions you have about using terminals so that you can bring it up in class
2. Be prepared to compare and contrast bash, shell, terminal, and git.
3. (optional) If you like to read about things before you do them, read about merge conflicts. If you prefer to see them first, read this after.

3.11. Experience Report Evidence

link to your github inclass repo

3.12. Questions After Today's Class

3.12.1. Are the things we learned in the terminal available to revisit later on?

Yes, in these notes!

3.12.2. what's the difference between `git checkout` and `git pull`, i used pull in 305 a lot

`git pull` updates the **same** branch you are on. It calls `git fetch` and then does some extra stuff. `git checkout` switches branches

3.12.3. What situations would you use the terminal over something like VScode for?

really quick edits where the time spent to open and configure VSCode does not pay off

3.12.4. Will we learn how to fix mistakes in the terminal? As in commands we did not mean to run

Yes, for the things that can be fixed, we will also see what commands cannot be undone and what safeties are built into CLI tools.

3.12.5. Im curious about the benefits to viewing files in the terminal as opposed to quick viewing them in finder, or other things that seem to be easier outside of terminal

Viewing a file in finder when we know it is really small and only text requires **context switching** which makes it more work. Using a GUI can be an easier way to start, it is less to remember, but once you know how things work you cannot make them any faster, you have to move your mouse so far, wait for things to load, etc. The terminal lets you gain speed once you learn.

You can also automate and script things.

Finally, sometimes a GUI is a waste of resources that you do not have to spare.

4. How do git branches work?

4.1. Review

Recall, We can move around and examine the computer's file structure using shell commands.

```
cd Documents/inclass/systems/github-inclass-fa23-brownsarahm/
```

To confirm our current working directory we print it with `pwd`

```
pwd
```

```
/Users/brownsarahm/Documents/inclass/systems/github-inclass-fa23-brownsarahm
```

this confirms what we expect

Now let's see what is in our folder:

```
ls
```

```
README.md      about.md
```

and check in with git

```
git status
```

```
On branch 1-create-an-about-file
Your branch is up to date with 'origin/1-create-an-about-file'.
```

```
nothing to commit, working tree clean
```

this is as we left off.

4.2. Branches do not sync automatically

Now we will look in GitHub and see what is there.

[Skip to main content](#)

⚠ Warning

the step below requires that you have the `gh` CLI. On windows with GitBash, you have not needed this, and it can be bit tricky to install. If you get it done and working well, and you submit instructions to this repo about how to get it set up, for either a community badge (if it's simple) or an explore badge if it takes a lot

```
gh repo view --web
```

Opening github.com/introcompsys/github-inclass-fa23-brownsarahm in your browser.

On Github, we see that it matches the branch we were on because we had merged in our PR in class on Thursday.

```
git status
```

```
On branch 1-create-an-about-file
Your branch is up to date with 'origin/1-create-an-about-file'.

nothing to commit, working tree clean
```

Back on our local computer, we will go back to the main branch, using `git checkout`

```
git checkout main
```

```
Switched to branch 'main'
Your branch is up to date with 'origin/main'.
```

now we look at the status of our repo:

```
ls
```

```
README.md
```

the file is missing. It said it was up to date with origin main, but that is the most recent time we checked github only. It's up to date with our local record of what is on GitHub, not the current GitHub.

Next, we will update locally, with `git fetch`

```
git fetch
```

```
remote: Enumerating objects: 1, done.
remote: Counting objects: 100% (1/1), done.
remote: Total 1 (delta 0), reused 0 (delta 0), pack-reused 0
Unpacking objects: 100% (1/1), 646 bytes | 215.00 KiB/s, done.
From https://github.com/introcompsys/github-inclass-fa23-brownsarahm
  6a12db0..caeacb5  main    -> origin/main
```

[Skip to main content](#)

Here we see 2 sets of messages. Some lines start with “remote” and other lines do not. The “remote” lines are what `git` on the GitHub server said in response to our request and the other lines are what `git` on your local computer said.

So, here, it counted up the content, and then sent it on GitHub’s side. On the local side, it unpacked (remember git compressed the content before we sent it). It describes the changes that were made on the GitHub side, the main branch was moved from one commit to another. So it then updates the local main branch accordingly (“Updating 6a12db0...caeacb5”).

We can see that this updates the working directory too:

```
ls
```

```
README.md
```

no changes yet. `fetch` updates the .git directory so that git knows more, but does not update our local file system.

We can use `git pull` to fully update.

```
git pull
```

```
Updating 6a12db0..caeacb5
Fast-forward
 about.md | 2 ++
 1 file changed, 2 insertions(+)
 create mode 100644 about.md
```

```
ls
```

```
README.md      about.md
```

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

nothing to commit, working tree clean
```

Now we will follow the instruction in the README issue, commit to a new branch with `[closes #x]` where x is the issue number in the comment and make PR.

Merge the PR and then the issue closes.

4.3. Pull will download and update

We will `git pull` again now all at once, this will do the work that `fetch` did before and the `checkout`.

```
git pull
```

[Skip to main content](#)

```
remote: Enumerating objects: 6, done.
remote: Counting objects: 100% (6/6), done.
remote: Compressing objects: 100% (4/4), done.
remote: Total 4 (delta 1), reused 0 (delta 0), pack-reused 0
Unpacking objects: 100% (4/4), 1.32 KiB | 337.00 KiB/s, done.
From https://github.com/introcompsys/github-inclass-fa23-brownsarahm
  caeacb5..5c8aaa9  main      -> origin/main
 * [new branch]  add-name  -> origin/add-name
Updating caeacb5..5c8aaa9
Fast-forward
 README.md | 4 +---
 1 file changed, 4 insertions(+)
```

We can see commits with `git log`

```
git log
```

```
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (HEAD -> main, origin/main, origin/HEAD)
Merge: caeacb5 65e9e39
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Tue Sep 19 12:47:08 2023 -0400

  Merge pull request #5 from introcompsys/add-name

  closes #2

commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Tue Sep 19 12:46:00 2023 -0400

  closes #2

commit caeacb503cf4776f075b848f0faff535671f2887
Merge: 6a12db0 693a2b5
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Thu Sep 14 13:38:54 2023 -0400

  Merge pull request #4 from introcompsys/1-create-an-about-file

  create and complete about file closes #1

commit 693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file)
Author: Sarah M Brown <brownsarahm@uri.edu>
Date:   Thu Sep 14 13:36:03 2023 -0400

  create and complete about file closes #1

commit 6a12db0035e7c73772f7b2348b80dd0bfb3a2a2e
Author: github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com>
Date:   Thu Sep 14 16:43:07 2023 +0000

  Add online IDE url

commit cfe32e5066921ad876d8a2c74b1fcbb00c99b1cc7
Author: github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com>
Date:   Thu Sep 14 16:43:05 2023 +0000

  Initial commit
```

this is a program, we can use enter/down arrow to move through it and then `q` to exit.

```
git status
```

[Skip to main content](#)

```
Your branch is up to date with 'origin/main'.  
nothing to commit, working tree clean
```

```
git pull
```

```
Already up to date.
```

4.4. making a new branch locally

We've used `git checkout` to switch branches before. To also create a branch at the same time, we use the `-b` option.

```
git checkout -b fun_fact
```

```
Switched to a new branch 'fun_fact'
```

```
git log
```

Note

notice where each branch pointer is

```
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (HEAD -> fun_fact, origin/main, origin/HEAD, main)  
Merge: caeacb5 65e9e39  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:47:08 2023 -0400
```

Merge pull request #5 from introcompsys/add-name

closes #2

```
commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:46:00 2023 -0400
```

closes #2

```
commit caeacb503cf4776f075b848f0faff535671f2887  
Merge: 6a12db0 693a2b5  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Thu Sep 14 13:38:54 2023 -0400
```

Merge pull request #4 from introcompsys/1-create-an-about-file

create and complete about file closes #1

```
commit 693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file)  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Thu Sep 14 13:36:03 2023 -0400
```

create and complete about file closes #1

```
commit 6a12db0035e7c73772f7b2348b80dd0bfb3a2a2e
```

we used the [nano](#) text editor. [nano](#) is simpler than other text editors that tend to be more popular among experts, [vim](#) and [emacs](#). Getting comfortable with nano will get you used to the ideas, without putting as much burden on your memory. This will set you up to learn those later, if you need a more powerful terminal text editor.

```
nano about.md
```

this opens the nano program on the terminal. it displays reminders of the commands at the bottom of the screen and allows you to type into the file right away.

Add any fun fact on the line below your content... Then, write out (save), it will prompt the file name. Since we opened nano with a file name ([about.md](#)) specified, you will not need to type a new name, but to confirm it, by pressing enter/return.

My file looks like this.

```
Sarah Brown  
2027  
- i skied competitively in high school
```

```
git status
```

```
on branch fun_fact  
Changes not staged for commit:  
  (use "git add <file>..." to update what will be committed)  
  (use "git restore <file>..." to discard changes in working directory)  
    modified:   about.md  
  
no changes added to commit (use "git add" and/or "git commit -a")
```

This is very similar to when we checked after creating the file before, but, notice a few things are different.

- the first line tells us the branch but does not compare to origin. (this branch does not have a linked branch on GitHub)
- the file is listed as “not staged” instead of untracked
- it gives us the choice to add it to then commit OR to restore it to undo the changes

We will add it to stage

```
git add about.md
```

```
git status
```

```
on branch fun_fact  
Changes to be committed:  
  (use "git restore --staged <file>..." to unstage)  
    modified:   about.md
```

and commit:

⚠ Warning

here i gave an example of what to do if you commit without a message. This is not recommended, but important to know how to fix.

```
git commit
```

without a commit message it puts you in vim. Read the content carefully, then press `a` to get into ~insert~ mode. Type your message and/or uncomment the template.

When you are done use `escape` to go back to command mode, the ~insert~ at the bottom of the screen will go away. Then type `:wq` and press enter/return.

What this is doing is adding a temporary file with the commit message that git can use to compelte your commit.

```
[fun_fact 6d4dbd3] add fun fact  
1 file changed, 1 insertion(+)
```

Now we can look again at where our branch pointers are.

```
git log
```

fun_fact moved up to the new commit, but the other branches stayed behind.

```
commit 6d4dbd33860fcceb9c87bd3c4509deff8cecb3f45 (HEAD -> fun_fact)  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 13:06:54 2023 -0400  
  
add fun fact  
  
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (origin/main, origin/HEAD, main)  
Merge: caeacb5 65e9e39  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:47:08 2023 -0400  
  
Merge pull request #5 from introcompsys/add-name  
  
closes #2  
  
commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:46:00 2023 -0400  
  
closes #2  
  
commit caeacb503cf4776f075b848f0faff535671f2887  
Merge: 6a12db0 693a2b5  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Thu Sep 14 13:38:54 2023 -0400  
  
Merge pull request #4 from introcompsys/1-create-an-about-file  
  
create and complete about file closes #1  
  
commit 693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file)
```

Now we will push to github

[Skip to main content](#)

```
git push
```

```
fatal: The current branch fun_fact has no upstream branch.  
To push the current branch and set the remote as upstream, use  
  
    git push --set-upstream origin fun_fact  
  
To have this happen automatically for branches without a tracking  
upstream, see 'push.autoSetupRemote' in 'git help config'.
```

It cannot push, because it does not know where to push, like we noted above that it did not compare to origin, that was because it does not have an “upstream branch” or a corresponding branch on a remote server. It does not work at first because this branch does not have a remote.

git stores its list of remotes in a `.git/config` file

```
cat .git/config
```

```
[core]  
repositoryformatversion = 0  
filemode = true  
bare = false  
logallrefupdates = true  
ignorecase = true  
precomposeunicode = true  
[remote "origin"]  
url = https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git  
fetch = +refs/heads/*:refs/remotes/origin/*  
[branch "main"]  
remote = origin  
merge = refs/heads/main  
[branch "1-create-an-about-file"]  
remote = origin  
merge = refs/heads/1-create-an-about-file
```

we can see our other branches have `remote = origin` but our new branch is not there.

To fix it, we do as git said.

```
git push --set-upstream origin fun_fact
```

```
Enumerating objects: 5, done.  
Counting objects: 100% (5/5), done.  
Delta compression using up to 8 threads  
Compressing objects: 100% (3/3), done.  
Writing objects: 100% (3/3), 311 bytes | 311.00 KiB/s, done.  
Total 3 (delta 1), reused 0 (delta 0), pack-reused 0  
remote: Resolving deltas: 100% (1/1), completed with 1 local object.  
remote:  
remote: Create a pull request for 'fun_fact' on GitHub by visiting:  
remote:     https://github.com/introcompsys/github-inclass-fa23-brownsarahm/pull/new/fun_fact  
remote:  
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git  
 * [new branch]      fun_fact -> fun_fact  
branch 'fun_fact' set up to track 'origin/fun_fact'.
```

This time the returned message from the remote includes the link to the page to make a PR. We are not going to make the PR though

4.5. Merge conflicts

First, in your browser edit the [about.md](#) file to have a second fun fact.

Then edit it locally to also have 2 fun facts.

```
nano about.md
```

```
cat about.md
```

```
Sarah Brown  
2027  
- I skied competitively in high school  
- I went to Northeastern
```

now that we have edited in both places let's pull.

```
git pull
```

```
remote: Enumerating objects: 5, done.  
remote: Counting objects: 100% (5/5), done.  
remote: Compressing objects: 100% (3/3), done.  
remote: Total 3 (delta 1), reused 0 (delta 0), pack-reused 0  
Unpacking objects: 100% (3/3), 697 bytes | 174.00 KiB/s, done.  
From https://github.com/introcompsys/github-inclass-fa23-brownsarahm  
  6d4dbd3..768dec8  fun_fact  -> origin(fun_fact)  
Updating 6d4dbd3..768dec8  
error: Your local changes to the following files would be overwritten by merge:  
      about.md  
Please commit your changes or stash them before you merge.  
Aborting
```

First it does not work because we have not committed.

This is helpful because it prevents us from losing any work.

```
git status
```

```
On branch fun_fact  
Your branch is behind 'origin(fun_fact)' by 1 commit, and can be fast-forwarded.  
(use "git pull" to update your local branch)  
  
Changes not staged for commit:  
(use "git add <file>..." to update what will be committed)  
(use "git restore <file>..." to discard changes in working directory)  
      modified:   about.md  
  
no changes added to commit (use "git add" and/or "git commit -a")
```

```
git commit -a -m 'second fun fact'
```

```
[fun_fact b378bd1] second fun fact  
1 file changed, 1 insertion(+)
```

Now we try to pull again

```
git pull
```

```
hint: You have divergent branches and need to specify how to reconcile them.  
hint: You can do so by running one of the following commands sometime before  
hint: your next pull:  
hint:  
hint:   git config pull.rebase false  # merge  
hint:   git config pull.rebase true   # rebase  
hint:   git config pull.ff only      # fast-forward only  
hint:  
hint: You can replace "git config" with "git config --global" to set a default  
hint: preference for all repositories. You can also pass --rebase, --no-rebase,  
hint: or --ff-only on the command line to override the configured default per  
hint: invocation.  
fatal: Need to specify how to reconcile divergent branches.
```

Now it cannot work because the branches have diverged. This illustrates the fact that our two versions of the branch `fun_fact` and `origin(fun_fact)` are two separate things.

gitGraph commit commit branch fun_fact checkout fun_fact commit branch origin(fun_fact) checkout origin(fun_fact) commit
checkout fun_fact commit

the branches have diverged means that they do not agree and that they each have at least one commit that is different from the other.

```
git log
```

```
commit b378bd148e53dfa7195c58123362e40ae12ef3e7 (HEAD -> fun_fact)  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 13:26:20 2023 -0400  
  
    second fun fact  
  
commit 6d4dbd33860fcceb9c87bd3c4509deff8cecb3f45  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 13:06:54 2023 -0400  
  
    add fun fact  
  
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (origin/main, origin/HEAD, main)  
Merge: caeacb5 65e9e39  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:47:08 2023 -0400  
  
    Merge pull request #5 from introcompsys/add-name  
  
    closes #2  
  
commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)  
Author: Sarah Brown <brownsarahm@uri.edu>  
Date: Tue Sep 19 12:46:00 2023 -0400
```

[Skip to main content](#)

```
commit caeacb503cf4776f075b848f0faff535671f2887
Merge: 6a12db0 693a2b5
Author: Sarah Brown <brownsarahm@uri.edu>
Date: Thu Sep 14 13:38:54 2023 -0400
```

git gave us some options, we will use `rebase` which will apply our local commits *after* the remote commits.

```
git pull --rebase
```

```
Auto-merging about.md
CONFLICT (content): Merge conflict in about.md
error: could not apply b378bd1... second fun fact
hint: Resolve all conflicts manually, mark them as resolved with
hint: "git add/rm <conflicted_files>", then run "git rebase --continue".
hint: You can instead skip this commit: run "git rebase --skip".
hint: To abort and get back to the state before "git rebase", run "git rebase --abort".
Could not apply b378bd1... second fun fact
```

Now it tells us there is a conflict.

```
nano about.md
```

We see that git marked up the conflict for us by editing the file:

```
Sarah Brown
2027
- i skied competitively in high school
<<<<<< HEAD
- i started at URI in 2020
=====
- I went to Northeastern
>>>>>> "add fun fact"
```

We manually edit it to be what we want it to be. We can take one change the other or both. We will choose both, so my file looks like this in the end.

```
cat about.md
```

```
Sarah Brown
2027
- i skied competitively in high school
- i started at URI in 2020
- I went to Northeastern
```

Now, we do `git add`, because above it said that was the next step.

```
git add about.md
```

and then this was the next thing after that.

⚠ Warning

If you got something very different at this point, run `git --version` mine is 2.41. If yours is different, let me know as an issue.

```
git rebase --continue
```

```
[detached HEAD 756c487] second fun fact
 1 file changed, 2 insertions(+)
Successfully rebased and updated refs/heads/fun_fact.
```

Once we rebase and everything is done, we can push.

```
git push
```

```
Enumerating objects: 5, done.
Counting objects: 100% (5/5), done.
Delta compression using up to 8 threads
Compressing objects: 100% (3/3), done.
Writing objects: 100% (3/3), 312 bytes | 312.00 KiB/s, done.
Total 3 (delta 2), reused 0 (delta 0), pack-reused 0
remote: Resolving deltas: 100% (2/2), completed with 2 local objects.
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
 768dec8..756c487  fun_fact -> fun_fact
```

4.6. Prepare for Next Class

1. Read the notes from 2023-09-19 carefully
2. Examine an open source project on GitHub. Answer the reflection questions below in `software.md` in your kwl repo on a branch that is linked to this issue. You do not need to make the PR, we will work with this in class on 2023-09-21.

```
## Software Reflection

1. Link and title of the project
1. What types of files are there that are not code?
1. What different types of code files are in the project? Do they serve different goals?
1. Is it all in one language or are there multiple languages?
1. Are there files that are configurations or settings?
1. Is there help for developers? users? which support is better?
1. What type of things are in the hidden files? who would need to see those files vs not?
```

Some open source projects if you do not have one in mind:

- pandas
- numpy
- GitHub CLI
- Rust language
- vs code
- Typescript

- Jupyter book

4.7. Review today's class

1. Create a merge conflict in your github in class repo and resolve it using your favorite IDE,. Describe how you created it, show the files, and describe how your IDE helps or does not help in ide_merge_conflict.md. Give advice for when you think someone should resolve a merge conflict manually vs using an IDE. (if you do not regularly use an, IDE, try VSCode)
2. Read more details about [git branches](#)(you can also use other resources) add [branches.md](#) to your KWL repo and describe how branches work, in your own words. Include one question you have about branches or one scenario you think they could help you with.

4.8. More Practice

1. Create a merge conflict in your github in class repo and resolve it using your favorite IDE, then create one and resolve it on GitHub in browser(this requires the merge conflict to occur on a PR). Describe how you created it, show the files, and describe how your IDE helps or does not help in ide_merge_conflict.md. Give advice for when you think someone should resolve a merge conflict in GitHub vs using an IDE. (if you do not regularly use an, IDE, try VSCode)
2. Learn about [GitHub forks](#) and more about [git branches](#)(you can also use other resources)
3. add [branches-forks.md](#) to your KWL repo and describe how branches work, what a fork is, and how they relate to one another. If you use other resources, include them in your file as markdown links.

4.9. Experience Report Evidence

Note

this is for if you miss class and need to make it up

run `git log >> inclass2023-09-19.md` and then copy that new file into your KWL repo on the branch for your experience report

4.10. Questions After Today's Class

4.10.1. How would you fix a merge conflict involving other people trying to commit on other systems?

The same way we did in class.

4.10.2. are there situations where if you accidentally make another branch, that you can merge it into the one you wanted to be working on?

yes, exactly!

4.10.3. could you fix a merge conflict in github rather than in the local terminal in some

[Skip to main content](#)

Yes, when the merge conflict arises as a result of a pull request and it is simple you can resolve it in [github.com](#)

4.10.4. What exactly does the rebase command do?

I described it in more detail above with links to git docs.

4.10.5. What point does using git locally give?

it's the only way to keep your work in git and also run code locally

4.10.6. Why were some of my command prompts different from yours?

Not sure, but it might be the version of git.

4.10.7. What website do you find the most useful to resolve issues relating to git within the terminal?

I tend to rely on using `git status` to see where it is at, thinking about where I want to get and then searching and using eg stackoverflow for things I do not know how to do.

that said `git gud` can help you visualize and we will have some other visualizations soon.

4.10.8. Would it be reasonable to never use the local Terminal and just always use github?

No, that means you would not be able to run your code to work. Even if you work on most cloud services, you still need to use the "local" terminal, on that cloud instance.

5. When do I get an advantage from git and bash?

so far we have used git and bash to accomplish familiar goals, and git and bash feel like just extra work for familiar goals.

Today, we will start to see why git and bash are essential skills: they give you efficiency gains and time traveling super powers (within your work only, sorry)

Further Reading

Use these for checking facts and resources.

- [bash](#)
- [git](#)

5.1. Setup

```
cd Documents/inclass/systems/github-inclass-fa23-brownsarahm/
```

and we will make sure we are in sync with GitHub. We know we *can* fix it, but it is best to not break it.

```
git status
```

```
On branch fun_fact
Your branch is up to date with 'origin/fun_fact'.

nothing to commit, working tree clean
```

Since our working tree is clean, now we can get updates from GitHub

```
git pull
```

```
Already up to date.
```

Now let's go back to the main branch.

```
git checkout main
```

```
Switched to branch 'main'
Your branch is up to date with 'origin/main'.
```

It tells us we are there.

Let's look at what commits are on the main branch.

```
git log
```

```
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (HEAD -> main, origin/main, origin/HEAD)
Merge: caeacb5 65e9e39
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Tue Sep 19 12:47:08 2023 -0400

    Merge pull request #5 from introcompsys/add-name

    closes #2

commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Tue Sep 19 12:46:00 2023 -0400

    closes #2

commit caeacb503cf4776f075b848f0faff535671f2887
Merge: 6a12db0 693a2b5
Author: Sarah Brown <brownsarahm@uri.edu>
Date:   Thu Sep 14 13:38:54 2023 -0400

    Merge pull request #4 from introcompsys/1-create-an-about-file
```

[Skip to main content](#)

```
commit 693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file)
Author: Sarah M Brown <brownsarahm@uri.edu>
Date: Thu Sep 14 13:36:03 2023 -0400
```

We remember that we had added fun facts and none of our commits about those are here, so the `fun_fact` branch is still ahead of the main branch.

It's something like this:

```
gitGraph commit commit commit commit branch fun_fact checkout fun_fact commit branch origin/fun_fact commit checkout
fun_fact commit merge origin/fun_fact
```

5.2. Merging a branch offline

We can merge branches locally, without making a pull request in GitHub.

```
git merge fun_fact
```

```
Updating 5c8aaa9..756c487
Fast-forward
 about.md | 4 +---
 1 file changed, 4 insertions(+)
```

It summarizes the changes.

Now we can use `git log` to see where our branches all point.

```
git log
```

```
commit 756c4879c0447db20980f73a26bc2ba072e08a6d (HEAD -> main, origin/fun_fact, fun_fact)
Author: Sarah M Brown <brownsarahm@uri.edu>
Date: Tue Sep 19 13:26:20 2023 -0400
```

second fun fact

```
commit 768dec80c5e0734476d476ae83376c9c786b6450
Author: Sarah Brown <brownsarahm@uri.edu>
Date: Tue Sep 19 13:21:31 2023 -0400
```

Update about.md

```
commit 6d4dbd33860fcceb9c87bd3c4509deff8cecb3f45
Author: Sarah M Brown <brownsarahm@uri.edu>
Date: Tue Sep 19 13:06:54 2023 -0400
```

add fun fact

```
commit 5c8aaa9f2a129d551b8cb2cb294676f63c4af410 (origin/main, origin/HEAD)
Merge: caeacb5 65e9e39
Author: Sarah Brown <brownsarahm@uri.edu>
Date: Tue Sep 19 12:47:08 2023 -0400
```

Merge pull request #5 from introcompsys/add-name

closes #2

```
commit 65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name)
```

[Skip to main content](#)

This c
merm
often
idea,
every
(files,
can a
merm
them

Visually, it is like this

```
gitGraph commit id:"0" commit id:"1" commit id:"2" commit id:"3" branch fun_fact checkout fun_fact commit id:"A" branch origin/fun_fact commit id:"B" checkout fun_fact merge origin/fun_fact commit id:"C" checkout main merge fun_fact
```

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 3 commits.
  (use "git push" to publish your local commits)
```

```
nothing to commit, working tree clean
```

It is ahead by 3 commits now because there were 3 commits on the fun_fact branch.

5.3. Organizing a project (workign with files)

A common question is about how to organize projects. While our main focus in this class session is the `bash` commands to do it, the task that we are going to do is to organize a hypothetical python project

next we are going to pretend we worked on the project and made a bunch of files

```
touch abstract_base_class.py helper_functions.py important_classes.py alternative_classes.py README.md LICENSE
```

New bash lessons:

- `touch` can accept a list of files to create
- a list in bash is space separated with no brackets

```
ls
```

```
API.md          about.md        setup.py
CONTRIBUTING.md abstract_base_class.py test_alt.py
LICENSE.md       alternative_classes.py test_help.py
README.md        helper_functions.py test_imp.py
_config.yml      important_classes.py tests_abc.py
_toc.yml         overview.md
```

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 3 commits.
  (use "git push" to publish your local commits)
```

```
Untracked files:
  (use "git add <file>..." to include in what will be committed)
    API.md
    CONTRIBUTING.md
    LICENSE.md
    _config.yml
    _toc.yml
    abstract_base_class.py
```

[Skip to main content](#)

```
important_classes.py  
overview.md  
setup.py  
test_alt.py  
test_help.py  
test_imp.py  
tests_abc.py  
  
nothing added to commit but untracked files present (use "git add" to track)
```

5.4. Echo and redirects

`cat` concatenates the contents of a file to stdout, which is a special file that our terminal reads

```
cat README.md
```

```
# GitHub Practice  
  
Name: Sarah Brown  
  
[!][Open in Codespaces](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061)
```

`echo` allows us to send a message to stdout.

```
ehco "age=35"
```

```
-bash: ehco: command not found
```

For example, we can echo our age

```
echo "age=35"
```

```
age=35
```

We can also **redirect** the contents of a command from stdout to a file in `bash` like file operations while programming there is a similar concept to this mode.

There are two types of redirects, like there are two ways to write to a file, more generally:

- overwrite (`>`)
- append (`>>`)

```
echo "age=35" >> README.md
```

this command has no output, but we can use `cat` to view the file to see its impact.

```
cat README.md
```

```
# GitHub Practice
```

Name: Sarah Brown

[![Open in Codespaces](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061age=35)](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061age=35)

Now we see the text at the bottom of the file.

5.5. commit and add has limitations

Now we have made some changes we want, so let's commit our changes.

Last class we saw we can add and commit at the same time

```
git commit -a -m 'start organizing'
```

```
[main bc28179] start organizing
 1 file changed, 1 insertion(+)
```

This is way fewer things than we have done recently (remember we also made all of those files with touch)

lets check `git status` again

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 4 commits.
  (use "git push" to publish your local commits)

Untracked files:
  (use "git add <file>..." to include in what will be committed)
    API.md
    CONTRIBUTING.md
    LICENSE.md
    _config.yml
    _toc.yml
    abstract_base_class.py
    alternative_classes.py
    helper_functions.py
    important_classes.py
    overview.md
    setup.py
    test_alt.py
    test_help.py
    test_imp.py
    tests_abc.py

nothing added to commit but untracked files present (use "git add" to track)
```

The `-a` option on a commit does not add untracked files

We have to explicitly add those files.

```
git add .
```

[Skip to main content](#)

Now we can commit the content.

```
git commit -m 'start organizng for real'
```

```
[main d76bc52] start organizng for real
 15 files changed, 0 insertions(+), 0 deletions(-)
 create mode 100644 API.md
 create mode 100644 CONTRIBUTING.md
 create mode 100644 LICENSE.md
 create mode 100644 _config.yml
 create mode 100644 _toc.yml
 create mode 100644 abstract_base_class.py
 create mode 100644 alternative_classes.py
 create mode 100644 helper_functions.py
 create mode 100644 important_classes.py
 create mode 100644 overview.md
 create mode 100644 setup.py
 create mode 100644 test_alt.py
 create mode 100644 test_help.py
 create mode 100644 test_imp.py
 create mode 100644 tests_abc.py
```

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 5 commits.
  (use "git push" to publish your local commits)

nothing to commit, working tree clean
```

5.6. Redirect file modes

Now, let's go back to thinking about redirects. We saw that with two `>>` we appended to the file. With just *one* what happens?

```
echo "age=35" > README.md
```

We check the file now

```
cat README.md
```

```
age=35
```

It wrote over. One `>` writes to the file in overwrite mode.

Note

mode is a good vocab term that could be added to the site glossary for a community badge

5.7 Recovering from mistakes with git restore

[Skip to main content](#)

This would be bad, we lost content, but this is what git is for!

It is very very easy to undo work since our last commit.

This is good for times when you have something you have an idea and you do not know if it is going to work, so you make a commit before you try it. Then you can try it out. If it doesn't work you can undo and go back to the place where you made the commit.

To do this, we will first check in with git

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 5 commits.
  (use "git push" to publish your local commits)

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   README.md

no changes added to commit (use "git add" and/or "git commit -a")
```

Notice that it tells us what to do ([use "git restore <file>..." to discard changes in working directory](#)). The version of README.md that we broke is in the working directory but not committed to git, so git refers to them as "changes" in the working directory.

```
git restore README.md
```

Now lets check with git.

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 5 commits.
  (use "git push" to publish your local commits)

nothing to commit, working tree clean
```

Our working tree is clean now.

and it looks like it did before the > line. and we can check the file too

```
cat README.md
```

```
# GitHub Practice
Name: Sarah Brown
[! [Open in Codespaces] (https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061
age=35)
```

[Skip to main content](#)

Back how we wanted it!

5.8. What are these files?

We can use a redirect to add a bunch of text to the README file.

```
echo "|file | contents |
> | -----| -----
> | abstract_base_class.py | core abstract classes for the project |
> | helper_functions.py | utilty funtions that are called by many classes |
> | important_classes.py | classes that inherit from the abc |
> | alternative_classes.py | classes that inherit from the abc |
> | LICENSE.md | the info on how the code can be reused|
> | CONTRIBUTING.md | instructions for how people can contribute to the project|
> | setup.py | file with function with instructions for pip |
> | tests_abc.py | tests for constructors and methods in abstract_base_class.py|
> | tests_helpers.py | tests for constructors and methods in helper_functions.py|
> | tests_imp.py | tests for constructors and methods in important_classes.py|
> | tests_alt.py | tests for constructors and methods in alternative_classes.py|
> | API.md | jupyterbook file to generate api documentation |
> | _config.yml | jupyterbook config for documentation |
> | _toc.yml | jupyter book toc file for documentation |
> | philosophy.md | overview of how the code is organized for docs |
> | example.md | myst notebook example of using the code |
> | scratch.ipynb | jupyter notebook from dev |" >> README.md
```

this explains each file a little bit more than the name of it does. We see there are sort of 5 groups of files:

- about the project/repository
- code that defines a python module
- test code
- documentation
- extra files that “we know” we can delete.

We can see what it does with `cat`

```
cat README.md
```

```
# GitHub Practice

Name: Sarah Brown

[![Open in Codespaces](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061
age=35
|file | contents |
> | -----| -----
> | abstract_base_class.py | core abstract classes for the project |
> | helper_functions.py | utilty funtions that are called by many classes |
> | important_classes.py | classes that inherit from the abc |
> | alternative_classes.py | classes that inherit from the abc |
> | LICENSE.md | the info on how the code can be reused|
> | CONTRIBUTING.md | instructions for how people can contribute to the project|
> | setup.py | file with function with instructions for pip |
> | tests_abc.py | tests for constructors and methods in abstract_base_class.py|
> | tests_helpers.py | tests for constructors and methods in helper_functions.py|
> | tests_imp.py | tests for constructors and methods in important_classes.py|
> | tests_alt.py | tests for constructors and methods in alternative_classes.py|
> | API.md | jupyterbook file to generate api documentation |
```

[Skip to main content](#)

```
> | philosophy.md | overview of how the code is organized for docs |
> | example.md | myst notebook example of using the code |
> | scratch.ipynb | jupyter notebook from dev |
```

Note

using the open quote `"` then you stay inside that until you close it. when you press enter the command does not run until after you close the quotes

We can see how the `"` allows us to go on multiple lines this way:

```
echo "sldkjfds
>
>
>
>
>
>
>
>
>
> "
```

and it will output all of the blank lines

```
sldkjfds
```

5.9. Getting organized

Recall, we have just created a bunch of files.

```
ls
```

API.md	about.md	setup.py
CONTRIBUTING.md	abstract_base_class.py	test_alt.py
LICENSE.md	alternative_classes.py	test_help.py
README.md	helper_functions.py	test_imp.py
_config.yml	important_classes.py	tests_abc.py
_toc.yml	overview.md	

First, we'll make a directory with `mkdir`

```
mkdir docs
```

we can use `ls` to see the files that exist

```
ls
```

API.md	about.md	overview.md
--------	----------	-------------

[Skip to main content](#)

press
more
bash
prompt
still working
commands

```
README.md      docs      test_help.py  
_config.yml   helper_functions.py  test_imp.py  
_toc.yml      important_classes.py tests_abc.py
```

5.10. Moving Files

next we will move a file there with `mv`

We can see how to use this by getting the error when we do not pass any arguments.

```
mv
```

```
usage: mv [-f | -i | -n] [-v] source target  
         mv [-f | -i | -n] [-v] source ... directory
```

we get an error message that tells us how to use the command, it takes two arguments: source and target.

5.10.1. Help in GitBash

```
mv --help
```

```
mv: illegal option -- -  
usage: mv [-f | -i | -n] [-v] source target  
         mv [-f | -i | -n] [-v] source ... directory
```

This only give a basic version on mac, but is more on Git Bash

5.10.2. Getting help on *nix systems

`man` shows the manfile for help for a specific command

```
man mv
```

It opens in a program, then we need to use `q` to exit.

5.10.3. Back to moving.

```
mv overview.md docs/
```

what this does is change the path of the file from `.../github-inclass-brownsarahm-1/overview.md` to `.../github-inclass-brownsarahm-1/docs/overview.md`

This doesn't return anything, but we can see the effect with `ls`

```
API.md          about.md      setup.py
CONTRIBUTING.md abstract_base_class.py test_alt.py
LICENSE.md       alternative_classes.py test_help.py
README.md        docs          test_imp.py
_config.yml     helper_functions.py tests_abc.py
_toc.yml        important_classes.py
```

We can also use `ls` with a relative or absolute path of a directory to list the location instead of our current working directory.

```
ls docs/
```

```
overview.md
```

5.10.4. Moving multiple files with patterns

let's look at the list of files again.

```
ls
```

```
API.md          about.md      setup.py
CONTRIBUTING.md abstract_base_class.py test_alt.py
LICENSE.md       alternative_classes.py test_help.py
README.md        docs          test_imp.py
_config.yml     helper_functions.py tests_abc.py
_toc.yml        important_classes.py
```

We have lots with similar names.

We can use the `*` wildcard operator to move all files that match the pattern. We'll start with the two `.yml` (`yaml`) files that are both for the documentation.

```
mv *.yml docs/
```

Again, we confirm it worked by seeing that they are no longer in the working directory.

```
ls
```

```
API.md          abstract_base_class.py setup.py
CONTRIBUTING.md alternative_classes.py test_alt.py
LICENSE.md       docs          test_help.py
README.md        helper_functions.py test_imp.py
about.md        important_classes.py tests_abc.py
```

and that they are in `docs`

```
ls docs/
```

[Skip to main content](#)

Next we will work on the test files

```
mkdir tests
```

5.11. Renaming Files

We see that most of the test files start with `test_` but one starts with `tests_`. We could use the pattern `test*.py` to move them all without conflicting with the directory `tests/` but we also want consistent names.

We can use `mv` to change the name as well. This is because “moving” a file and is really about changing its path, not actually copying it from one location to another and the file name is a part of the path.

```
mv tests
```

Here I pressed tab multiple times trying to get tab complete, but since it was not unique, it showed me the two options.

```
tests/      tests_abc.py
```

Then I added `_` and pressed tab again to get its full file name.

```
mv tests_abc.py test_abc.py
```

This changes the path from `.../tests_abc.py` to `.../test_abc.py` to. It is doing the same thing as when we use it to move a file from one folder to another folder, but changing a different part of the path.

```
ls
```

API.md	alternative_classes.py	test_alt.py
CONTRIBUTING.md	docs	test_help.py
LICENSE.md	helper_functions.py	test_imp.py
README.md	important_classes.py	tests
about.md	setup.py	
abstract_base_class.py	test_abc.py	

Then we can use a similar pattern to move the files.

```
mv test_*.py tests/
```

Now we can confirm that it is how we expect.

```
ls
```

API.md	about.md	helper_functions.py
CONTRIBUTING.md	abstract_base_class.py	important_classes.py
LICENSE.md	alternative_classes.py	setup.py
README.md	docs	tests

[Skip to main content](#)

i Not

this is
import
organ
can u
yours

```
ls tests/
```

```
test_abc.py    test_alt.py    test_help.py    test_imp.py
```

5.12. Committing Changes

we check where we are

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 5 commits.
  (use "git push" to publish your local commits)

Changes not staged for commit:
  (use "git add/rm <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   README.md
    deleted:   _config.yml
    deleted:   _toc.yml
    deleted:   overview.md
    deleted:   test_alt.py
    deleted:   test_help.py
    deleted:   test_imp.py
    deleted:   tests_abc.py

Untracked files:
  (use "git add <file>..." to include in what will be committed)
    docs/
    tests/

no changes added to commit (use "git add" and/or "git commit -a")
```

```
git add docs/
```

```
git status
```

```
On branch main
Your branch is ahead of 'origin/main' by 5 commits.
  (use "git push" to publish your local commits)

Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
    new file:  docs/_config.yml
    new file:  docs/_toc.yml
    new file:  docs/overview.md

Changes not staged for commit:
  (use "git add/rm <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   README.md
    deleted:   _config.yml
    deleted:   _toc.yml
    deleted:   overview.md
    deleted:   test_alt.py
    deleted:   test_help.py
```

[Skip to main content](#)

```
Untracked files:  
(use "git add <file>..." to include in what will be committed)  
tests/
```

```
git add .
```

```
git commit -m 'begin organizing'  
>  
>  
> '
```

```
[main 042a42e] begin organizing  
8 files changed, 19 insertions(+)  
rename _config.yml => docs/_config.yml (100%)  
rename _toc.yml => docs/_toc.yml (100%)  
rename overview.md => docs/overview.md (100%)  
rename test_alt.py => tests/test_abc.py (100%)  
rename test_help.py => tests/test_alt.py (100%)  
rename test_imp.py => tests/test_help.py (100%)  
rename tests_abc.py => tests/test_imp.py (100%)
```

ANd finally push

```
git push
```

```
Enumerating objects: 13, done.  
Counting objects: 100% (13/13), done.  
Delta compression using up to 8 threads  
Compressing objects: 100% (10/10), done.  
Writing objects: 100% (11/11), 1.72 KiB | 1.72 MiB/s, done.  
Total 11 (delta 3), reused 0 (delta 0), pack-reused 0  
remote: Resolving deltas: 100% (3/3), done.  
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git  
 5c8aaa9..042a42e main -> main
```

5.13. experience badge with a file

1. Run the action to create the branch for today's experience badge
2. Open a PR to propose changes from your prepare work brach to the branch for today's experience badge
3. merge that PR
4. See that in your experience badge, the prepare work is now visible
5. fill in your experience badge
6. request a review from the TA that is in your group

5.14. Prepare for Next Class

1. Review your [software.md](#) file from last prepare
2. Review the notes from 2023-09-21

3. Bring git questions or scenarios you want to be able to solve to class on Thursday (in your mind or comment here if that helps you remember)
4. Update your `.github/workflows/experienceinclass.yml` file as to add another parameter to the last step ([Create Pull request](#)) `reviewers: <ta-gh-name>` where `<ta-gh-name>` is the github user name of the TA in your group. You can see your group on the organisation teams page named like "Fall 2023 Group X". Do this on a branch for this issue.

5.15. Review today's class

badge steps marked **lab** are steps that you will be encouraged to use lab time to work on.

1. Update your KWL chart with the new items and any learned items.
2. Clone the course website. Append the commands used and the contents of your `fall2023/.git/config` to a `terminal_review.md` (hint: history outputs recent commands and redirects can work with any command, not only echo). Edit the `README.md`, commit, and try to push the changes. What happens and what GitHub concept that we have not used yet might fix it? see your `vocab-` repo for a list of key github concepts. (answer in the `terminal_review.md`)
3. **lab** Organize the provided messy folder in a Codespace (details will be provided in lab time). Commit and push the changes. Answer the questions below in your kwl repo in a file called `terminal_organization.md`
4. clone your `messy_repo` locally and append the `history.md` file to your `terminal_organization.md`
5. Find your team's repository. It will have a name like `fa23-team#` where `#` is a number 1-4. Join the discussion on that repo about naming your team. Link to your comment directly in your PR for this badge (use the 3 dots menu to get the comment specific URL).

`# Terminal File moving reflection`

1. How was this activity overall? Did this get easier toward the end?
2. When do you think that using the terminal will be better than using your GUI file explorer?
3. What questions/challenges/ reflections do you have after this exercise?

`## Commands used`

5.16. More Practice

badge steps marked **lab** are steps that you will be encouraged to use lab time to work on.

1. Update your KWL chart with any learned items.
2. Get set up so that you can pull from the introcompsyss/fall2023 repo and push to your own fork of the class website by cloning the main repo, then forking it and adding your fork as an additional `remote`. Append the commands used and the contents of your `fall2023/.git/config` to a `terminalpractice.md` (hint: `history` outputs recent commands and redirects can work with any command, not only echo). Based on what you know so far about forks and branches, what advantage does this setup provide? (answer in the `terminal_practice.md`)
3. **lab** Organize the provided messy folder (details will be provided in lab time). Commit and push the changes. Clone that repo locally.
4. For extra practice, re/organize a folder on your computer (good candidate may be desktop or downloads folder), using only a terminal to make new directories, move files, check what's inside them, etc. Answer reflection questions in a new file, `terminal_organization_adv.md` in your kwl repo. Tip: Start with a file explorer open, but then try to close it, and use only command line tools to explore and make your choices. If you get stuck, look up additional commands to do accomplish your goals.

5. Find your team's repository. It will have a name like `fa23-team#` where `#` is a number 1-4. Join the discussion on that repo about naming your team. Link to your comment directly in your PR for this badge (use the 3 dots menu to get the comment specific URL).

`# Terminal File moving reflection`

1. How was this activity overall Did this get easier toward the end?
2. How was it different working on your own computer compared to the Codespace from?
3. Did you have to look up how to do anything we had not done in class?
4. When do you think that using the terminal will be better than using your GUI file explorer?
5. What questions/challenges/ reflections do you have after this?
6. Append all of the commands you used in lab below. (not from your local computer's history, from the codespace)

5.17. Experience Report Evidence

redirect the history to a file

```
history >> makeup_2023-09-21.md
```

then move the file created to your KWL repo on your experience report branch.

5.18. Questions After Today's Class

5.18.1. Why does git not see new directories added to the repo while they're empty?

git only tracks *files* not directories. It also makes note of the path to each file.

5.18.2. After a new directory has new files in it git status only shows the directory name but not the files within it. Why is that?

It is saying that there is a file there that is untracked, but leaves it at the directory level to give you the choice to add/ignore the whole directory at once

5.18.3. If possible, is it common to echo a line of code into a programming file?

Yes!

5.18.4. What other experience will we have with open source projects in this class?

We will use mostly open source tools and you can do an explore or build to learn more.

5.18.5. How can the "*" be used consistently to move a bunch of files? because we used it with the text in front of the similarity and behind it. I'm just wondering how it's used for multiple files, because it was used both before the similarity and after the similarity.

It fills in for any number of characters

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5.18.6. I have some badges from 2 weeks ago that are awaiting a second review after changes had been fixed.

⚠ Important

Do not merge an unapproved badge

Re-request a review

5.18.7. can you close pull requests on the terminal?

Not with git because pull requests are not a git feature, but it is a feature of github. The [gh](#) CLI can do this.

5.18.8. If you do mv * will it move all files?

In the current working directory.

5.18.9. Are there any other ways of using mv that haven't been covered yet?

No those are basically the two purposes.

5.18.10. how often should we be practicing with the terminal for git?

Ideally, you work on badges on at least several of the days we do not have class so that you are working with it close to every day.

You could also start trying to use them for your other classes.

5.18.11. Would it be beneficial to organize files with github rather than bash?

GitHub cannot organize files and doing do in browser would be slow and difficult. We will see that GitHub code spaces give us a virtual machine that we can work with.

6. What is a commit?

⚠ Warning

Due to events beyond my control the full details for this class were lost. Below contains all of the notes and explanation, but not every command that was run and the actual output at each step.

No notes yet because I made an error and did not save my terminal output from the codespace before I left the classroom.

To produce the notes, I will have to use the commit history and the prismia log to re-do the activity in a copy of my repo that I manipulate to undo things so that I can recreate.

6.1. Housekeeping

6.1.1. In class time

reminder: you are expected to follow along with what I model in my terminal and use prismia as a backup if you miss something or get an error.

6.1.2. Notifications

reminder: I post announcements as releases

To get notified, watch the repo.

6.1.3. Penalty free zone is over.

- all past badges can be submitted at any time
- all badges posted today going forward have deadlines per the syllabus

6.2. Why study what a commit is?

A commit is the most important unit of git. Later we will talk about what git as a whole is in more detail, but understanding a commit is essential to understanding how to fix things using git.

today we will continue organizing the github inclass repo as our working example.

In CS we often have multiple, overlapping definitions for a concept depending on our goal.

In intro classes, we try really hard to only use one definition for each concept to let you focus.

Now we need to contend with multiple definitions.

These definitions could be based on

- what it conceptually represents
- its role in a larger system
- what its parts are
- how it is implemented

6.3. Using a GitHub Codespace

Today we will also work in github codespaces.

1. Navigate to your github inclass repo on [Github.com](#)
2. Use the link in the README or the green code button to open a new codespace on main.

You are allowed to have two active code spaces at any point in time. If you get an error, you have some still open. Use the

You can deactivate any that are running that you do not want to use.

! Important

Remember: codespace is a virtual machine on a cloud platform, not cloud access to [github.com](#)

- you need to commit changes
- codespace is linux

this is why i teach bash

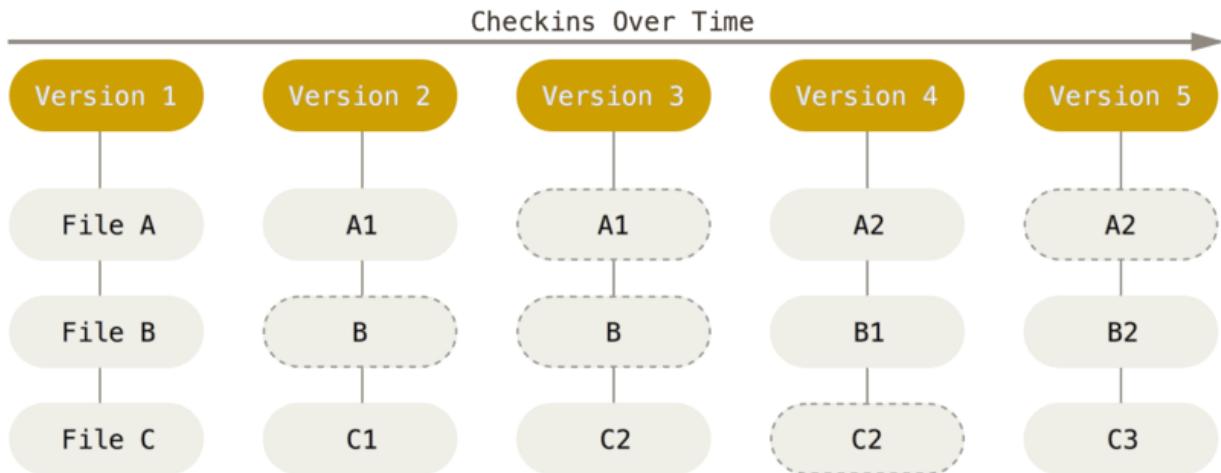
as developers, we will all interact with linux/unix at times, so bash is the best shell to know if you only know one or do not want to switch between multiple

6.4. Multiple cursors are your friend

[docs](#)

We used multiple cursors to remove the `>` from the beginning of each line in the README file that we made last class.

6.5. Conceptually, a commit is a snapshot



6.6. A commit is the basic unit of what git manages

All other git objects are defined relative to commits

- branches are pointers to commits
- tags are pointers to commits

6.7. parts of a commit

We can use `git log` to view past commits

[Skip to main content](#)

- hash
- (if merge)
- author
- time stamp
- message

but we know commits are supposed to represent some content and we have no information about that in this view

we can view individual commits with

```
git cat-file
```

Now we see more detail:

- hash (used to access)
- tree
- parent
- author with timestamp
- committer with timestamp
- message

6.8. Commit parents help us trace back

kind of like a linked list

6.9. Commit trees are the hash of the content

This separation is helpful.

Let's make a commit that includes changes to two files

After the commit we can use

```
git reset HEAD^
```

to put the head pointer back and reset the working directory back to how it was at that point as well.

The `git reset` docs describe this in great detail.

6.10. Commit messages are essential

A git commit message must exist and is *always* for people, but can also be for machines.

the conventional commits standard is a format of commits

if you use this, then you can use automated tools to generate a full change log when you release code

6.11. Prepare for Next Class

1. Read the 2023-09-26 notes when posted
2. Make sure that the `gh` CLI tool works by using it to create an issue called test on your kwl repo with `gh issue create`
3. Take a few minutes to think about a time you were debugging or pay attention the next time you debug something. Make note of how you think about the problem, how do you decide what to check? how do you decide what to try? what information do you look for?

6.12. Review today's class

1. create an issue on your group repo for a tip or cheatsheet item you want to contribute. Make sure that your contribution does not overlap with one that amemb
2. clone your group repo.
3. work offline and add your contribution and then open a PR
4. review a class mate's PR.
5. Export your git log for your KWL main branch to a file called `gitlog.txt` and commit that as exported to the branch for this issue. **note that you will need to work between two branchse to make this happen.** Append a blank line, `## Commands`, and another blank line to the file, then the command history used for this exercise to the end of the file.

6.13. More Practice

1. Find a resource/reference that helps explain a topic related to the course that you want to review. Make sure that your contribution does not overlap with one that another member is going to post by viewing other issues before you post your issue. Create an issue for your planned item.
2. Clone your group repo.
3. Work offline to add your contribution and then open a PR. Your reference review should help a classmate decide if that reference material will help them understand better or not. It should summarize the material and its strengths/weaknesses.
4. Complete a peer review of a class mate's PR. Use inline comments for any minor corrections, provide a summary, and either approve or request changes.
5. learn about options for how git can display commit history. Try out a few different options. Choose two, write them both to a file, `gitlog-compare.md`. Using a text editor, wrap each log with three backticks to make them "code blocks" and then add text to the file describing a use case where that format in particular would be helpful.

6.14. Experience Report Evidence

write your `git log` to a file and include it with your experience report.

6.15. Questions After Today's Class

6.15.1. Can you use the terminal for any IDE that is not only VScode in Codespaces?

Yes.

6.15.2. What is the difference between using git reset and git revert?

git revert applies a new commit that is the opposite of the one that you want to “undo” reset actuall resets everything back to a particular point.

6.15.3. How can I learn more neat tricks like multicursor?! Very usefull and I do not know how I have never known about it.

I think most developers learn things like this from talking to one another or reading blogs/watching youtube/ following on social media.

We will have a class on IDEs later, where one of the tasks is for you all to share tips.

6.15.4. Is there always a way to return to a state of a repo, no matter how far along or how much as been committed or changed?

Yes

6.15.5. What does the commit message convention you showed us in class do? It needs a script to attach to it but what is the end goal of the scripts?

It allows a script to process the commit messages in order to produce a change log.

 **Important**

Learning more about this or using it throughout could be an explore/build badge

6.15.6. Is there a way to write a script to automate this process so that I don't need to write as many commands?

Yes we will write scripts in a few weeks.

6.15.7. Is it more efficient to look for the commit id and create a branch off it in the terminal rather than to do it manually in github?

Often yes.

6.15.8. Do you know of some situations where restore saved the worst possible mistakes in a repo?

Yes, reverting and restoring helps fix bugs all the time. It is also how people can remove data that should have never been committed, before pushing.

7. How do programmers communicate about code?

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Today we are going to pick up from where we left off talking about the conventional commits.

That is a core example of the types of detailed communication we do in programming that is embedded into the work.

7.1. Closing your Codespace

Use the [codespace](#) page to see all of yours.

Check that your github-in-class repo has no uncommitted changes. If it does you need to commit them, there are two strategies:

- start the codespace, commit and push
- from that page, export the changes to a branch, create a PR and merge it if needed

7.2. Build and Explore Ideas

I am going to put ideas in the [discussions](#) repo

I violated the instructions a little, but I thought it made the most sense.

7.3. Why Documentation

Today we will talk about documentation, there are several reasons this is important:

- **using** official documentation is the best way to get better at the tools
- understanding how documentation is designed and built will help you use it better
- **writing** and **maintaining** documentation is really important part of working on a team
- documentation building tools are a type of developer tool (and these are generally good software design)

Design is best learned from examples. Some of the best examples of software *design* come from developer tools.

- [source \(js version\)](#)
- [source \(python version\)](#)

In particular documentation tools are really good examples of:

- pattern matching
- modularity
- automation
- building

By the end of today's class you will be able to:

- describe different types of documentation
- find different information in a code repo
- generate documentation as html
- ignore content from a repo
- create a repo locally and push to GitHub

7.4. What is documentation

Note

We opened this page and discussed the different types of documentation in the table in class

documentation types table

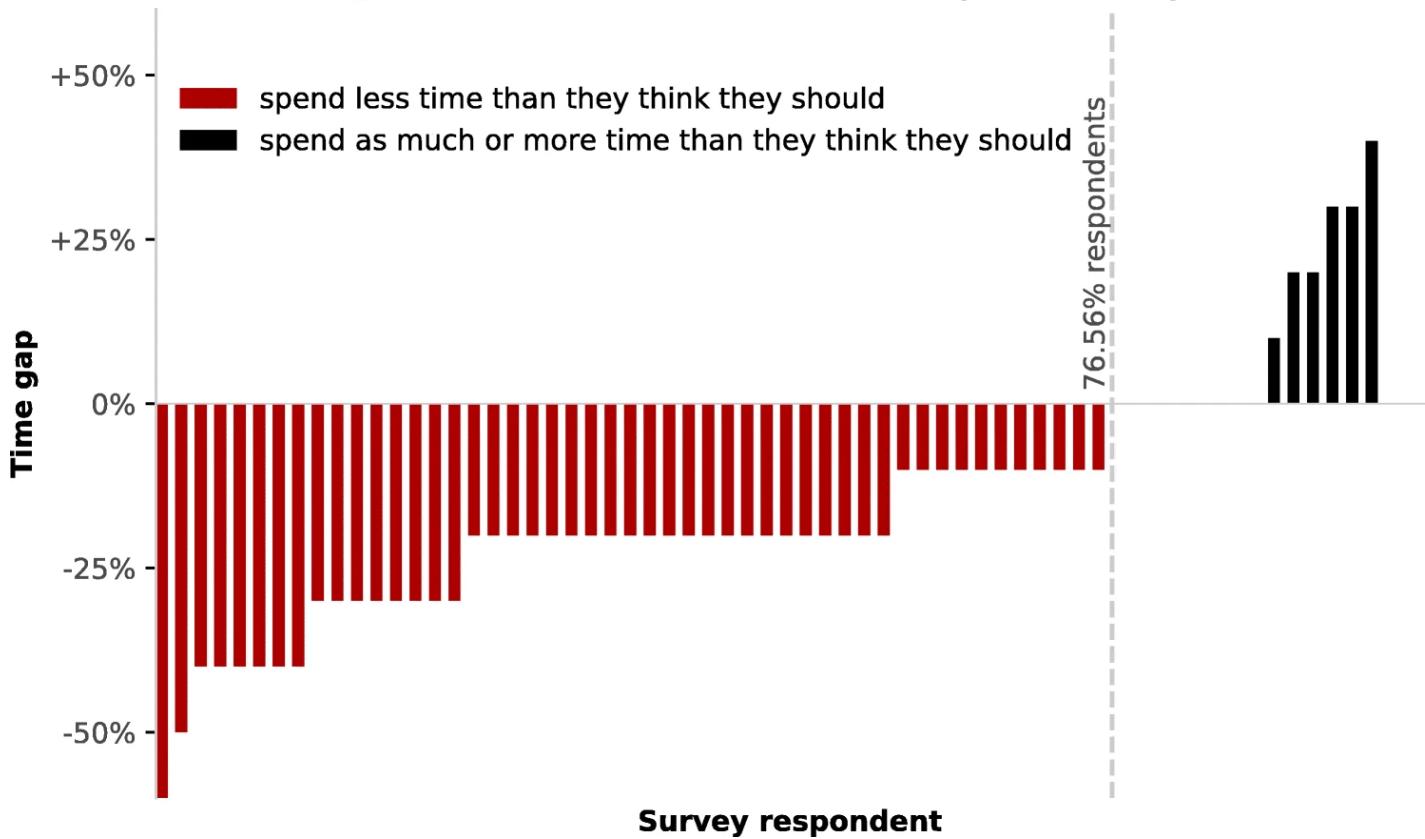
from ethnography of documentation data science

Data Science is only one type of programming, but this is still pretty representative. The main difference is that in this case the “target” users are often data scientists and more technically skilled than the “target” users of, for example, a social media app. This would mean that user-facing docs would vary.

7.5. Why is documentation so important?

we should probably spend more time on it

Less than 25% of respondents spend as much or more time writing documentation than what they think they should.



via source

7.6. What is a docstring

```
Python 3.11.4 (main, Jul 5 2023, 09:00:44) [Clang 14.0.6 ] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> help(print)

>>> def ex():
...     ''' doc string
...
...     padd
...
>>> help(ex)

>>>
>>> # a comment
>>> exit()
```

7.7. So, how do we do it?

Documentation Tools

write the docs

linux kernel uses sphinx and here is [why](#) and how it works

7.8. Install Jupyter-book

[Jupyterbook](#) wraps sphinx and uses markdown instead of restructured text. The project authors note in the documentation that it "can be thought of as an *opinionated distribution of Sphinx*". We're going to use this, so that we can use most of the power of sphinx without having to learn ReStructured Text which is more complex than markdown syntax.

[install jupyterbook](#) on Mac or linux those instructions will work on your regular terminal, if you have python installed. On Windows those instructions will work in the Anaconda prompt or any other terminal that is set up with python. If these steps do not make sense see the [recommendations](#) in the syllabus for more instructions including videos of the Python install process in both Mac and Windows.

```
pip install jupyter-book
```

Note

this command does a lot of stuff, it installs [jupyter-book](#) and all of its dependencies, which is a lot. I removed the output from the notes

the thing that matters is that near the end it will say "successfully installed"

Now we move to our inclass repo:

```
cd Documents/inclass/systems/
ls
```

```
github-inclass-fa23-brownsarahm
```

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And note that we can see the other folders we have made so far, but note that we are *not inside* any of them.

We can create this

```
jupyter-book create tiny-book
```

```
=====
Your book template can be found at
tiny-book/
=====
```

and it tells us the relative path to the new folder, we can use `ls` again to see that it is there.

```
ls
```

```
github-inclass-fa23-brownsarahm tiny-book
```

7.9. Parts of a Jupyter book

First we go in the directory:

```
cd tiny-book/
```

Then look

```
ls
```

```
_config.yml          logo.png        notebooks.ipynb
_toc.yml            markdown-notebooks.md  references.bib
intro.md           markdown.md      requirements.txt
```

7.9.1. starting a git repo locally

Before we work with the files, let's commit the current version

```
git status
```

```
fatal: not a git repository (or any of the parent directories): .git
```

We cannot check status because we are not in a git repo.

Recall a git repo is a folder that contains a `.git` directory with the versions of our project in it. This directory is typically hidden, so

[Skip to main content](#)

```
ls -a
```

```
.           intro.md      notebooks.ipynb  
..          logo.png     references.bib  
_config.yml    markdown-notebooks.md  requirements.txt  
_toc.yml      markdown.md
```

We can create a new repo with `git init` and the path to where we want it. We want it at our current working directory, which is `.`

```
git init .
```

```
hint: Using 'master' as the name for the initial branch. This default branch name  
hint: is subject to change. To configure the initial branch name to use in all  
hint: of your new repositories, which will suppress this warning, call:  
hint:  
hint:   git config --global init.defaultBranch <name>  
hint:  
hint: Names commonly chosen instead of 'master' are 'main', 'trunk' and  
hint: 'development'. The just-created branch can be renamed via this command:  
hint:  
hint:   git branch -m <name>  
Initialized empty Git repository in /Users/brownsarahm/Documents/inclass/systems/tiny-book/.git/
```

Here we are faced with a social aspect of computing that is *also* a good reminder about how git actually works

7.9.2. Retiring racist language

Historically the default branch was called master.

- derived from a master/slave analogy which is not even how git works, but was adopted terminology from other projects
- GitHub no longer does
- the broader community is changing as well
- git allows you to make your default not be master
- literally the person who chose the names “master” and “origin” regrets that choice the name main is a more accurate and not harmful term and the current convention.

we'll change our default branch to main

```
git branch -m main
```

Now, we can look at the directory to see how `git init` changed the folder.

```
ls -a
```

```
.           _toc.yml      markdown.md  
..          intro.md     notebooks.ipynb  
.git        logo.png     references.bib  
_config.yml    markdown-notebooks.md  requirements.txt
```

and

```
git status
```

```
on branch main  
No commits yet  
Untracked files:  
(use "git add <file>..." to include in what will be committed)  
_config.yml  
_toc.yml  
intro.md  
logo.png  
markdown-notebooks.md  
markdown.md  
notebooks.ipynb  
references.bib  
requirements.txt  
nothing added to commit but untracked files present (use "git add" to track)
```

it works!

and we will commit the template.

```
git add .
```

```
git commit -m 'init jupyterbook'
```

```
[main (root-commit) 3fcd849] init jupyterbook  
9 files changed, 341 insertions(+)  
create mode 100644 _config.yml  
create mode 100644 _toc.yml  
create mode 100644 intro.md  
create mode 100644 logo.png  
create mode 100644 markdown-notebooks.md  
create mode 100644 markdown.md  
create mode 100644 notebooks.ipynb  
create mode 100644 references.bib  
create mode 100644 requirements.txt
```

7.9.3. Structure of a Jupyter book

```
ls
```

_config.yml	logo.png	notebooks.ipynb
_toc.yml	markdown-notebooks.md	references.bib
intro.md	markdown.md	requirements.txt

A jupyter book has two required files (`_config.yml` and `_toc.yml`), some for content, and some helpers that are common but not required.

- toc file formatting rules
- the `*.md` files are content
- the `.bib` file is bibliography information
- The other files are optional, but common. `Requirements.txt` is the format for pip to install python dependencies. There are different standards in other languages for how

the extention (`.yml`) is `yaml`, which stands for “YAML Ain’t Markup Language”. It consists of key, value pairs and is deigned to be a human-friendly way to encode data for use in any programming language.

7.9.4. Dev tools mean we do not have to write bibliographies manually

bibliographies are generated with `bibtex` which takes structured information from the references in a `bibtex` file with help from `sphinxcontrib-bibtex`

For general reference, reference managers like `zotero` and `mendeley` can track all of your sources and output the references in `bibtex` format that you can use anywhere or sync with tools like MS Word or Google Docs.

7.9.5. Configuration options

The config file template is pretty complete, including the URL of the webpage with all of the detailed setting options.

The configuration file, tells jupyter-book basic iformation about the book, it provides all of the settings that jupyterbook and sphinx need to render the content as whatever output format we want.

```
cat _config.yml
```

```
# Book settings
# Learn more at https://jupyterbook.org/customize/config.html

title: My sample book
author: The Jupyter Book Community
logo: logo.png

# Force re-execution of notebooks on each build.
# See https://jupyterbook.org/content/execute.html
execute:
    execute_notebooks: force

# Define the name of the latex output file for PDF builds
latex:
    latex_documents:
        targetname: book.tex

# Add a bibtex file so that we can create citations
bibtex_bibfiles:
    - references.bib

# Information about where the book exists on the web
repository:
    url: https://github.com/executablebooks/jupyter-book # Online location of your book
    path_to_book: docs # Optional path to your book, relative to the repository root
    branch: master # Which branch of the repository should be used when creating links (optional)

# Add GitHub buttons to your book
# See https://jupyterbook.org/customize/config.html#add-a-link-to-your-repository
html:
```

7.9.6. Content Organization

The table of contents file describe how to put the other files in order.

```
cat _toc.yml
```

```
# Table of contents
# Learn more at https://jupyterbook.org/customize/toc.html

format: jb-book
root: intro
chapters:
- file: markdown
- file: notebooks
- file: markdown-notebooks
```

7.9.7. Building a book

We can transform from raw source to an output by **building** the book

Building is transforming from input to output format. In this case from markdown, yaml, and notebook files into HTML.

We will see later that building is also what we refer to the whole process from source code to executable.

```
jupyter-book build .
```

```
Running Jupyter-Book v0.15.1
Source Folder: /Users/brownsarahm/Documents/inclass/systems/tiny-book
Config Path: /Users/brownsarahm/Documents/inclass/systems/tiny-book/_config.yml
Output Path: /Users/brownsarahm/Documents/inclass/systems/tiny-book/_build/html
Running Sphinx v4.5.0
making output directory... done
[etoc] Changing master_doc to 'intro'
checking bibtex cache... out of date
parsing bibtex file /Users/brownsarahm/Documents/inclass/systems/tiny-book/references.bib... parsed 5 entries
myst v0.18.1: MdParserConfig(commonmark_only=False, gfm_only=False, enable_extensions=['colon_fence', 'dollar'])
myst-nb v0.17.2: NbParserConfig(custom_formats={}, metadata_key='mystnb', cell_metadata_key='mystnb', kernel='')
Using jupyter-cache at: /Users/brownsarahm/Documents/inclass/systems/tiny-book/_build/.jupyter_cache
building [mo]: targets for 0 po files that are out of date
building [html]: targets for 4 source files that are out of date
updating environment: [new config] 4 added, 0 changed, 0 removed
/Users/brownsarahm/Documents/inclass/systems/tiny-book/markdown-notebooks.md: Executing notebook using local
0.00s - Debugger warning: It seems that frozen modules are being used, which may
0.00s - make the debugger miss breakpoints. Please pass -Xfrozen_modules=off
0.00s - to python to disable frozen modules.
0.00s - Note: Debugging will proceed. Set PYDEVD_DISABLE_FILE_VALIDATION=1 to disable this validation.
0.00s - Debugger warning: It seems that frozen modules are being used, which may
0.00s - make the debugger miss breakpoints. Please pass -Xfrozen_modules=off
0.00s - to python to disable frozen modules.
0.00s - Note: Debugging will proceed. Set PYDEVD_DISABLE_FILE_VALIDATION=1 to disable this validation.
/Users/brownsarahm/Documents/inclass/systems/tiny-book/markdown-notebooks.md: Executed notebook in 1.89 seconds
/Users/brownsarahm/Documents/inclass/systems/tiny-book/notebooks.ipynb: Executing notebook using local CWD []
0.00s - Debugger warning: It seems that frozen modules are being used, which may
0.00s - make the debugger miss breakpoints. Please pass -Xfrozen_modules=off
0.00s - to python to disable frozen modules.
0.00s - Note: Debugging will proceed. Set PYDEVD_DISABLE_FILE_VALIDATION=1 to disable this validation.
/Users/brownsarahm/Documents/inclass/systems/tiny-book/notebooks.ipynb: Executed notebook in 2.56 seconds
```

[Skip to main content](#)

```
pickling environment... done
checking consistency... done
preparing documents... done
writing output... [100%] notebooks
generating indices... genindex done
writing additional pages... search done
copying images... [100%] _build/jupyter_execute/137405a2a8521f521f06724f6d604e5a5544cce7bd94d903975cee58b0605
copying static files... done
copying extra files... done
dumping search index in English (code: en)... done
dumping object inventory... done
build succeeded.
```

```
The HTML pages are in _build/html.
[etoc] missing index.html written as redirect to 'intro.html'
```

```
=====
```

```
Finished generating HTML for book.
```

```
Your book's HTML pages are here:
```

```
    _build/html/
```

```
You can look at your book by opening this file in a browser:
```

```
    _build/html/index.html
```

```
Or paste this line directly into your browser bar:
```

```
file:///Users/brownsarahm/Documents/inclass/systems/tiny-book/_build/html/index.html
```

```
=====
```

💡 Try it yourself

Which files created by the template are not included in the rendered output? How could you tell?

```
ls
```

```
_build           logo.png      references.bib
_config.yml     markdown-notebooks.md requirements.txt
_toc.yml        markdown.md
intro.md         notebooks.ipynb
```

we note that this made a new folder called `_build`. we can look inside there.

```
ls _build/
```

```
html          jupyter_execute
```

and in the html folder:

```
ls _build/html/
```

```
_images          index.html      objects.inv
_sources         intro.html      search.html
_sphinx_design_static markdown-notebooks.html searchindex.js
_static          markdown.html
genindex.html    notebooks.html
```

We can also copy the path to the file and open it in our browser

we can change the size of a browser window or use the screen size settings in inspect mode to see that this site is responsive.

We didn't have to write any html and we got a responsive site!

If you wanted to change the styling with sphinx you can use built in themes which tell sphinx to put different files in the `_static` folder when it builds your site, but you don't have to change any of your content! If you like working on front end things (which is great! it's just not always the goal) you can even build [your own theme](#) that can work with sphinx.

7.10. Ignoring Built files

The built site files are completely redundant, content wise, to the original markdown files.

We do not want to keep track of changes for the built files since they are generated from the source files. It's redundant and makes it less clear where someone should update content.

```
git status
```

```
On branch main
Untracked files:
  (use "git add <file>..." to include in what will be committed)
    _build/
nothing added to commit but untracked files present (use "git add" to track)
```

```
ls
```

```
_build          logo.png        references.bib
_config.yml     markdown-notebooks.md  requirements.txt
_toc.yml        markdown.md      notebooks.ipynb
intro.md
```

Git helps us with this with the .gitignore

```
echo "_build/" >> .gitignore
```

```
git status
```

```
On branch main
Untracked files:
  (use "git add <file>..." to include in what will be committed)
    .gitignore
nothing added to commit but untracked files present (use "git add" to track)
```

now that's the only new file as far as git is concerned, so we will track this,

```
git commit -m 'ignores build'
```

```
[main 9c4157f] ignores build  
1 file changed, 1 insertion(+)  
create mode 100644 .gitignore
```

We can look at the file's contents

```
cat .gitignore
```

```
_build/
```

What it does is, when git goes to add, it skips any specific files that match both the `git add <path>` AND any of the paths listed in `.gitignore`

7.11. How do I push a repo that I made locally to GitHub?

Right now, we do not have any remotes

```
git remote
```

If we do the same in another repo that we got by cloning from GitHub, they all have remotes.

```
cd ../github-inclass-fa23-brownsarahm/  
git remote
```

```
origin
```

Typically they all use the default name `origin`

Back to our [tiny-book](#)

```
cd ../tiny-book/
```

For today, we will create an empty github repo shared with me using the link shared on prismia.

More generally, you can create a repo

That default page for an empty repo if you do not initiate it with any files will give you the instructions for what remote to add.

Now we add the remote, following the instructions from the blank repo page.

```
git remote add origin https://github.com/introcompsys/f23-tiny-book-brownsarahm.git
```

and finally we can push!

```
git push -u origin main
```

```
Enumerating objects: 14, done.  
Counting objects: 100% (14/14), done.  
Delta compression using up to 8 threads  
Compressing objects: 100% (12/12), done.  
Writing objects: 100% (14/14), 16.45 KiB | 8.23 MiB/s, done.  
Total 14 (delta 1), reused 0 (delta 0), pack-reused 0  
remote: Resolving deltas: 100% (1/1), done.  
To https://github.com/introcompsys/f23-tiny-book-brownsarahm.git  
 * [new branch]      main -> main  
branch 'main' set up to track 'origin/main'.
```

```
git remote
```

```
origin
```

7.12. Prepare for Next Class

1. Follow up on your grade plan PR and self reflection that you complete in lab

7.13. Review today's class

1. Review the notes, [jupyterbook docs](#), and experiment with the `jupyter-book` CLI to determine what files are required to make `jupyter-book build` run. Make your kwl repo into a jupyter book. Set it so that the `_build` directory is not under version control.
2. Add `docs.md` to your KWL repo and explain the most important things to know about documentation in your own words using other programming concepts you have learned so far. Include in a markdown (same as HTML `<!-- comment -->`) comment the list of CSC courses you have taken for context while we give you feedback.

7.14. More Practice

1. Review the notes, [jupyterbook docs](#), and experiment with the `jupyter-book` CLI to determine what files are required to make `jupyter-book build` run. Make your kwl repo into a jupyter book. Set it so that the `_build` directory is not under version control.
2. Learn about the documentation ecosystem in another language that you know using at least one official source and additional sources as you find helpful. In `docs.md` include a summary of your findings and compare and contrast it to jupyter book/sphinx. Include a [bibtex based bibliography](#) of the sources you used. You can use [this generator](#) for informal sources and [google scholar](#) for formal sources.

7.15. Experience Report Evidence

Tiny book repo should exist. Append your terminal output or this repo's git log to your experience report.

[Skip to main content](#)

7.16. Questions After Today's Class

7.16.1. Why would one experience missing .exe files within their python library, even after reinstalling python?

it is probably a missing path

7.16.2. If I want to track the _build file will it automatically be tracked now or do I have to remove it from gitignore?

To track the files in the build directory you would need to delete it from the `.gitignore` file.

Also, of note, git does not track folders, it tracks files, but listing folder paths can help

7.16.3. Will jupyter book look for a universal syntax for documentation or will it look for a language dependent syntax?

Default it works with Python, but the [sphinx docs](#) describe how to work with other languages. The jupyter book docs include a page on how [sphinx](#) and [jupyter-book](#) are related and a [page](#) on how to use other sphinx features in a jupyter book.

Jupyter notebooks also have [alternative kernels](#) so notebook styled pages can be written in these languages as well.

7.16.4. Can you create an entire repository with only git?

By definition git is what makes a git repository.

7.16.5. What is jupyter used for

Jupyter is a large software project designed to support computational sciences.

it includes the notebook file format specification, the lab interface for working with them, the hub for hosting it on a server.

Jupyter-book is a separate, but related, project that is highly compatible.

7.16.6. My question is related to hooking up to remote. It might be irrelevant now but could be a learning experience, I had trouble setting up my xcode local git repo with github, it kept giving an error about needing a ssh, eventually I got it working using some tutorials online but I'm wondering what would have made that happen.

This sounds like you may have copied the ssh url to the remote instead of the https version?

7.16.7. So pip3 install jupyter-book ended up not working up on Git Bash so I had to install Anaconda.Navigator. Now I am using the powershell prompt there. Should I expect massive differences even though I managed to catch up via the commands you posted in [Discussions](#)?

Python things do not work in GitBash by default, but do work in Anaconda Prompt, where git operations do not work. You may need to use two terminals, but should be able to do everything you need.

7.16.8. Is it possible to edit the Jupyter Book website on a web front site or does it have to be in the files?

You have to edit the source files not the built ones to keep the changes.

You can however, add custom HTML and/or CSS.

7.16.9. Are there alternatives to Jupyterbook that have similar functionality?

Yes, this is the practice badge.

7.16.10. If I want to track the _build file will it automatically be tracked now or do I have to remove it from .gitignore?

It has to not be in .gitignore to be tracked.

7.16.11. Will jupyter book look for a universal syntax for documentation or will it look for a language dependent syntax?

By default it looks for Python, but you can configure it to work with other languages.

Important

This is one thing you could do for a build badge.

7.17. Good Questions for Explore Badges

7.17.1. What other platforms/libraries are used to generate similar webpages?

Learning about the landscape of static site generators is a great topic.

8. What is git?

8.1. Admin

- I will be using [captioning](#) in classes going forward. This is not a persistent transcript, but instead an ephemeral, live, AI generated caption of all of what I say. At the start of each class, I will send the link to the page with the connection information for you to join the broadcast.
- To get credit for the course toward your major, use the [provided template for the curriculum modification form](#). Complete the

- Reminder: how to makeup experience badges
- Notice: minor revision to that process

Note

Notice, since the course website is a Jupyter book, if you look in the raw markdown for this page, the link to the form is the relative path. One of the advantages of using a static site generator of any kind is that you can create references like variables to refer to other parts of the document and the static site generator can

8.2. Today's goals

last week we learned about what a commit is and then we took a break from how git works, to talk more about how developers communicate

Today, we are going to learn *what* git is, next we will learn about *why* git and bash are designed the way they are designed and next week we will learn *how* git creates a commit

Study Tip

We will go in an out of topics at times, in order to provides what is called *spaced repetition* repeating material or key concepts with breaks.

Using git correctly is a really important goal of this course because git is an opportunity for you to demonstrate a wide range of both practical and conceptual understanding.

So, i have elected to interleave other topics with git to give core git ideas some time to simmer and give you time to practice them before we build on them with more depth at git.

Also, we are both learning git and *using* git as a motivating example of other key important topics.

8.3. Why are we defining git in week 5 of using it?

git book is the official reference on git.

Note

this includes other spoken languages as well if that is helpful for you.

From here, we have the full definition of git by the git developers:

git is fundamentally a content-addressable filesystem with a VCS user interface written on top of it.

—[git scm book]](<https://git-scm.com/book/en/v2/Git-Internals-Plumbing-and-Porcelain>)

We do not start from that point, because these documents were written for target audience of working developers who are familiar

Today, however, other version control systems are barely in use and this course is for computer science *students* and part of the goal is to learn what a Version Control System is.

8.4. Git is a File system

Let's break down the definition

Content-addressable filesystem means a key-value data store. What this means is that you can insert any kind of content into a Git repository, for which Git will hand you back a unique key you can use later to retrieve that content.

Other examples of key-value pairs you may have seen before include:

- python dictionaries
- pointers (address,content)
- parameter, passed values
- yaml files (from jupyter-book last week)

Again, we see that studying the developer tools is a good way to reinforce other concepts in computer science. Modularity and Abstraction are the core foundations of the field, and while they do have their limits of applicability, it means that if you get a really good understanding of the core abstractions, that makes learning other things in CS faster.

You can apply your past experience with these other concepts to help understand what to expect about how git works.

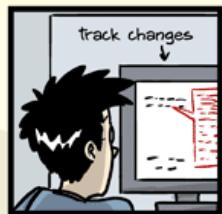
8.5. Git is a Version Control System

In the before times

"FINAL".doc



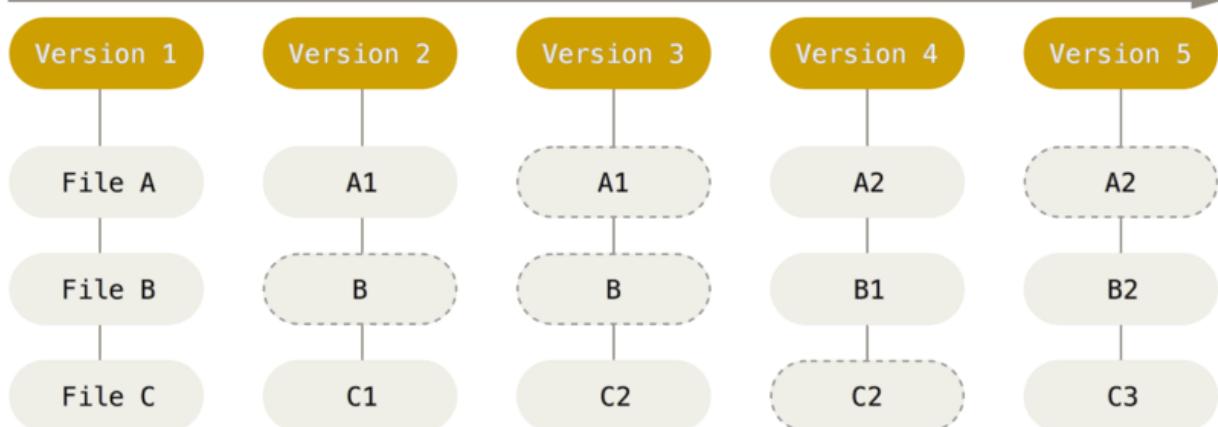
JORGE CHAM © 2012



WWW.PHDCOMICS.COM

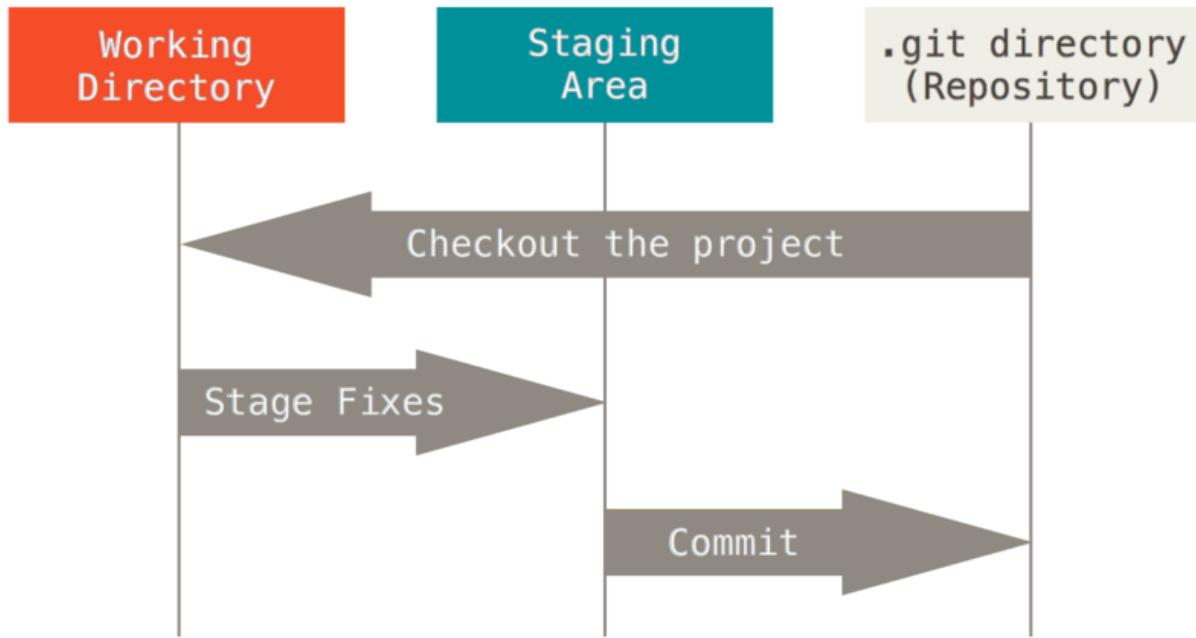
git stores **snapshots** of your work each time you commit.

Checkins Over Time →



it uses 3 stages:

[Skip to main content](#)



8.6. Git has two sets of commands

Porcelain: the user friendly VCS

Plumbing: the internal workings- a toolkit for a VCS

We have so far used git as a version control system. A version control system, in general, will have operations like commit, push, pull, clone. These may work differently under the hood or be called different things, but those are what something needs to have in order to keep track of different versions.

The plumbing commands reveal the way that git performs version control operations. This means, they implement file system operations for the git version control system.

You can think of the plumbing vs porcelain commands like public/private methods. As a user, you only need the public methods (porcelain commands) but those use the private ones to get things done (plumbing commands). We will use the plumbing commands over the next few classes to examine what git *really* does when we call the porcelain commands that we will typically use.

8.7. Git is distributed

What does that mean?

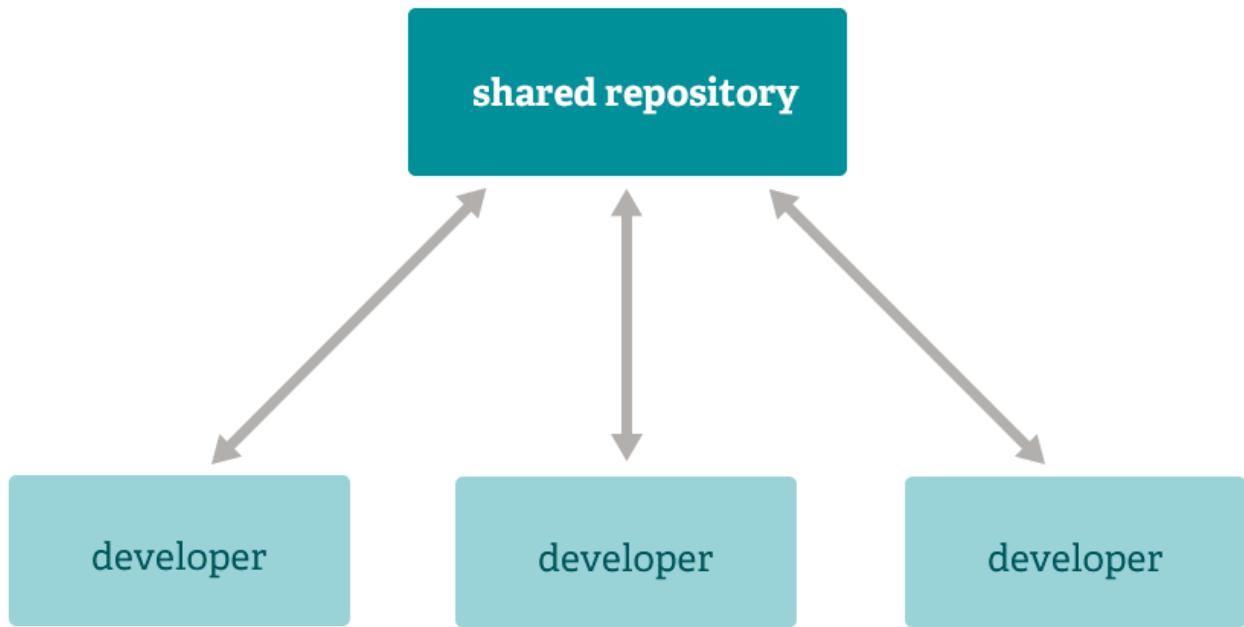
Git runs locally. It can run in many places, and has commands to help sync across remotes, but git does not require one copy of the repository to be the “official” copy and the others to be subordinate. git just sees repositories.

For human reasons, we like to have one “official” copy and treat the others as local copies, but that is a social choice, not a technological requirement of git. Even though we will typically use it with an official copy and other copies, having a tool that does not care, makes the tool more flexible and allows us to create workflows, or networks of copies that have any relationship we want.

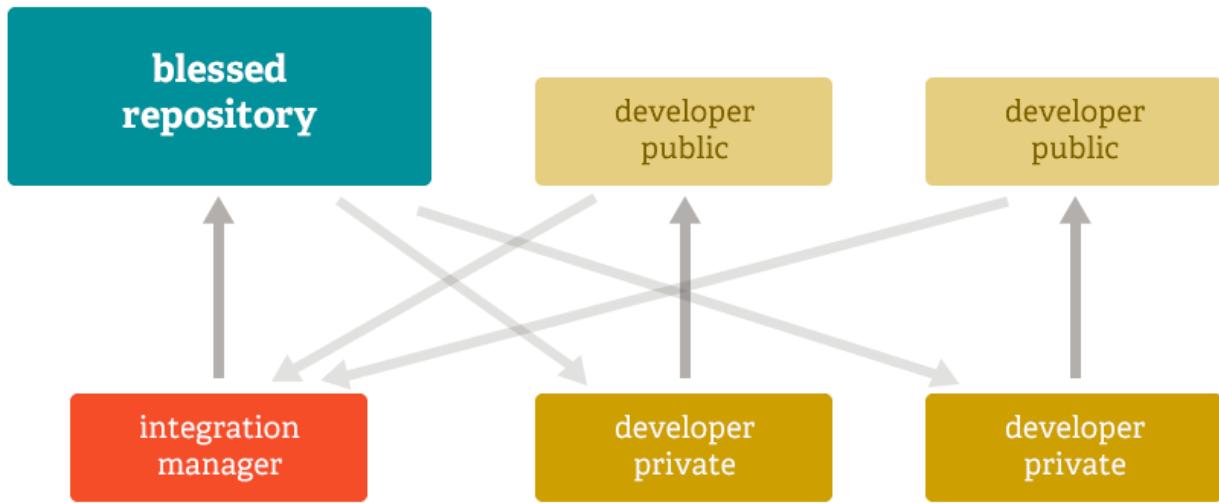
It's about the workflows, or the ways we socially use the tool.

Some example workflows include:

8.7.1. Subversion Workflow

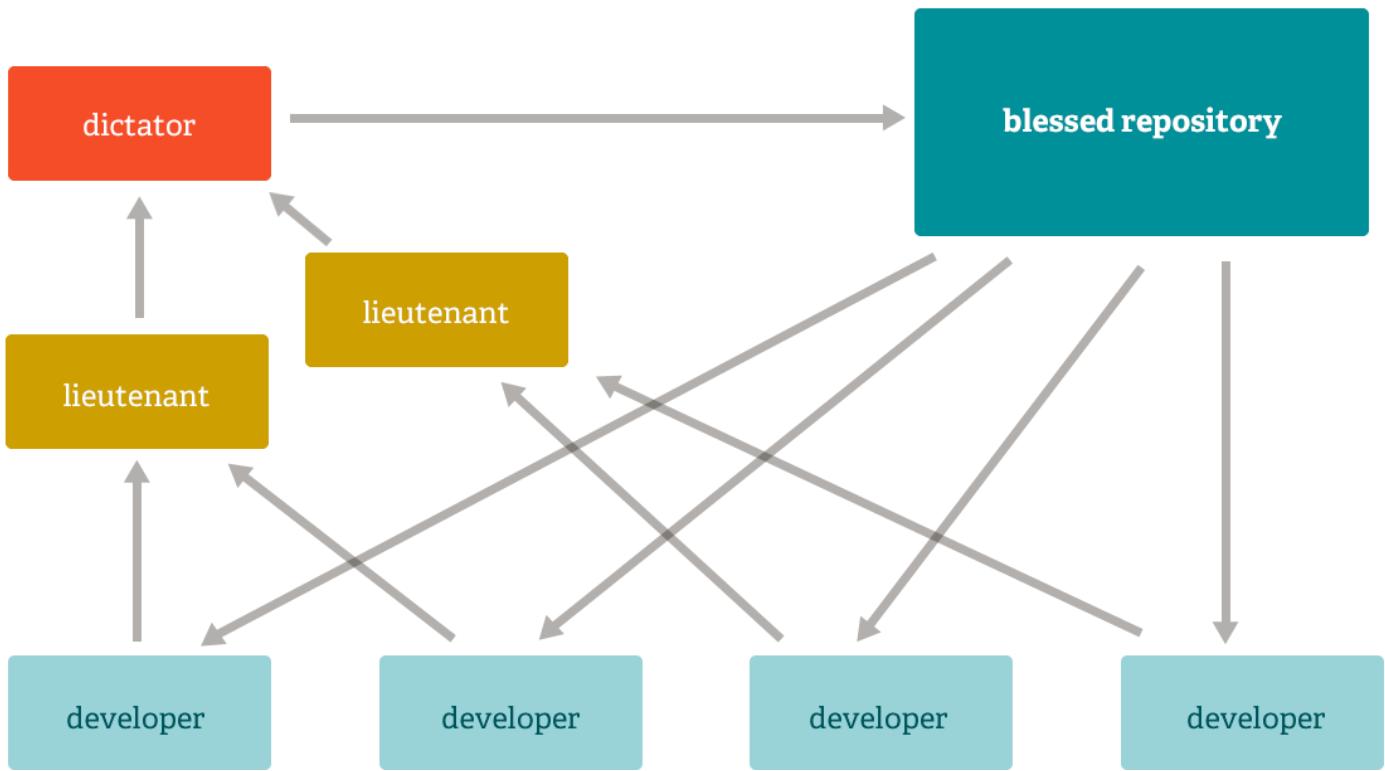


8.7.2. Integration Manager



8.7.3. dictator and lieutenants

In class these making I recommend sections



8.8. How does git do all these things?

Let's look at git again in our `github-inclass` repo.

I was still in my `tiny-book` repo so I went up one level, then used `ls` to remember the exact name of the `github-inclass` repo

```
cd ../
ls
```

```
github-inclass-fa23-brownsarahm tiny-book
```

We will change to the github inclass repo and use `pwd` to view the current working directory.

```
cd github-inclass-fa23-brownsarahm/
pwd
```

```
/Users/brownsarahm/Documents/inclass/systems/github-inclass-fa23-brownsarahm
```

We can use the bash command `find` to search the file system note that this does not search the contents of the files, just the names.

```
find .git/objects/ -type f
```

and we get this output:

```
.git/objects//04/ab89e167ed77bc2a95710f69f68d91a6219471  
.git/objects//69/3a2b5b9ad4c27eb3b50571b3c93dde353320a1  
.git/objects//93/4c15dc2655c988c981d9a836783afebda77355  
.git/objects//5a/a1ed29b82e1cebb8527019b0e594ba71dda214  
.git/objects//5f/e5a9821625fad2cca4c500e497e6694132c303  
.git/objects//d7/6bc523443bda5a5daae2fe7fcfbf6fb7a1ae6d  
.git/objects//b3/78bd148e53df7a195c58123362e40ae12ef3e7  
.git/objects//bc/281792d6ab62b153d7bf44f7985ec7cf3b850  
.git/objects//ca/eacb503cf4776f075b848f0faff535671f2887  
.git/objects//ca/feca302e31c65139b4a5294356e1ea8595dc81  
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.rev  
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.pack  
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.idx  
.git/objects//11/d53c24bb5d2bf2e3f645ef188f8bc75fa9c911  
.git/objects//45/fcb1dd311e5e45af759cb3627dca5f47f58f04  
.git/objects//75/6c4879c0447db20980f73a26bc2ba072e08a6d  
.git/objects//44/3f164cdde5059d78df6a61ca3f07bc6a605eb0  
.git/objects//43/a1267370f1af98071d53f8508abbc56fa3abde  
.git/objects//88/5588412d138cce89f06ffed5e83c316c2b593  
.git/objects//5c/8aaa9f2a129d551b8cb2cb294676f63c4af410  
.git/objects//65/e9e39935be8400ef12cc9003592f12244b50da  
.git/objects//3a/cf0fb1c2febd24561294bfb966e1ad1f033eb8  
.git/objects//98/96f7a7000a7b9d2fdb12047a141524358286c3  
.git/objects//37/0e04baf4f62d1e62f4949208bc5e4d33af5336  
.git/objects//6d/4dbd33860fce8c9c87bd3c4509def8cecb3f45  
.git/objects//39/f1c5eabb1458fa6cf9042611599b69665cf288  
.git/objects//55/56d17391aeee9b2b86d2821c011d7ed5377aa  
.git/objects//b8/6eb90ba1ae5504edfdc9ef8879e1c6d7a1b75  
.git/objects//b6/2d570421c3096d8c80c7df56357cd3203fd3a  
.git/objects//ea/c84c8320a3ab4f37a441a332b828c45ecedcc9  
.git/objects//e1/82616690a91a8d0e363f4143e68dd9e136ccee  
.git/objects//e6/9de29bb2d1d6434b8b29ae775ad8c2e48c5391  
.git/objects//8c/7cefb877c62a46a3b71c68a858c24075b379fe  
.git/objects//76/8dec80c5e0734476d476ae83376c9c786b6450  
.git/objects//2b/cb5d446129df427a1ce09e8ba658a5bb8ceca3
```

This is a lot of files! It's more than we have in our working directory.

```
ls
```

```
API.md           about.md          helper_functions.py  
CONTRIBUTING.md abstract_base_class.py important_classes.py  
LICENSE.md       alternative_classes.py setup.py  
README.md        docs              tests
```

This is a consequence of git taking snap shots and tracking both the actual contents of our working directory **and** our commit messages and other meta data about each commit. The content of the `.git/objects` is *everything* git knows about our project.

8.9. Git HEADS

If we look at the content of the `.git` directory there is always a file called `HEAD`

```
ls .git/
```

```
COMMIT_EDITMSG  ORIG_HEAD      description      info          packed-refs  
FETCH_HEAD     REBASE_HEAD    hooks            logs          refs  
HEAD           config         index           objects
```

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the program `git` does not run continuously the entire time you are using it for a project. It runs quick commands each time you tell it to, its goal is to manage files, so this makes sense. This also means that important information that `git` needs is also saved in files.

the files in all caps are like git's variables. Lets look at the one called `HEAD` we have interacted with `HEAD` before when resolving merge conflicts.

```
cat .git/HEAD
```

```
ref: refs/heads/main
```

`HEAD` is a pointer to the currently checked out branch.

the other `*HEAD` files are other "heads" or "tips" of the tree of commits. For example, I have one lingering from the last time I used `rebase` in my repo.

Note

You may or may not have the same heads that I do, because you may have missed a step or I may have done an extra thing in my repo to demo something to answer a question in office hours

```
cat .git/REBASE_HEAD
```

```
b378bd148e53dfa7195c58123362e40ae12ef3e7
```

This points to a specific commit, not a branch, because rebase occurs at a pair of specific commits, and does not move forward, this is sort of like a temporary variable, that does not get destroyed.

We should all have `ORIG_HEAD` which is `origin/head`

```
cat .git/ORIG_HEAD
```

```
5c8aaa9f2a129d551b8cb2cb294676f63c4af410
```

that points to a specific commit, instead of a branch.

We can see that git status matches what branch the `HEAD` file shows.

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.
```

```
nothing to commit, working tree clean
```

first, get the options,

```
git branch
```

```
1-create-an-about-file  
fun_fact  
* main
```

then `checkout` one of the existing branches

```
git checkout fun_fact
```

```
Switched to branch 'fun_fact'  
Your branch is up to date with 'origin/fun_fact'.
```

and we can confirm that one of the things `checkout` does is updates the head file:

```
cat .git/HEAD
```

```
ref: refs/heads(fun_fact
```

8.10. Branches are pointers to commits

Branches are implemented as files in `.git/refs/heads/` that contain the hash of the most recent commit “on” that branch. It’s useful to think of branches having multiple commits, and a tree like structure:

gitGraph commit commit branch fun_fact checkout fun_fact commit commit checkout main commit merge fun_fact commit
but literally, they are a pointer to a single commit. (remember each commit has a pointer to its “parent” or preceding commit)

We can see what commit a branch points to:

```
cat .git/refs/heads/fun_fact
```

```
756c4879c0447db20980f73a26bc2ba072e08a6d
```

`git branch` reads from the `.git/refs/heads` directory. It has some other options that make it more powerful, but its default behavior is very similar to

```
ls .git/refs/heads
```

```
1-create-an-about-file fun_fact main
```

⚠ Warning

This was an answer to a question, but I do not remember the question

```
cat .git/config
```

```
[core]
repositoryformatversion = 0
filemode = true
bare = false
logallrefupdates = true
ignorecase = true
precomposeunicode = true
[remote "origin"]
url = https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
fetch = +refs/heads/*:refs/remotes/origin/*
[branch "main"]
remote = origin
merge = refs/heads/main
[branch "1-create-an-about-file"]
remote = origin
merge = refs/heads/1-create-an-about-file
[branch "fun_fact"]
remote = origin
merge = refs/heads/fun_fact
```

8.11. Git Objects

Lets go back to the objects.

There are 3 types:

- blob objects: the content of your files (data)
- tree objects: stores file names and groups files together (organization)
- Commit Objects: stores information about the sha values of the snapshots

```
classDiagram
    title git object types
    class tree{
        List:
            - hash: blob
            - string: type
            - string: file name
    }
    class commit{
        hash: parent
        hash: tree
        string: message
        string: author
        string: time
    }
    class blob{
        binary: contents
    }
    class object{
        hash: name
    }
}
object <-- blob
```

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Again we can look at the list of objects:

```
find .git/objects/ -type f
```

```
.git/objects//04/2a42eb47c33ee43d793feb4d891a93e7460527
.git/objects//04/ab89e167ed77bc2a95710f69f68d91a6219471
.git/objects//69/3a2b5b9ad4c27eb3b50571b3c93dde353320a1
.git/objects//93/4c15dc2655c988c981d9a836783afebda77355
.git/objects//5a/a1ed29b82e1cebb8527019b0e594ba71dda214
.git/objects//5f/e5a9821625fad2cca4c500e497e6694132c303
.git/objects//d7/6bc523443bda5a5daae2fe7fcfbf6fba71ae6d
.git/objects//b3/78bd148e53dfa7195c58123362e40ae12ef3e7
.git/objects//bc/281792d6ab62b153d7bf44f7985ec7cfcb850
.git/objects//ca/eachb503cf4776f075b848f0faff535671f2887
.git/objects//ca/feca302e31c65139b4a5294356e1ea8595dcbb1
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.rev
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.pack
.git/objects//pack/pack-8631fedd908bc07c0b64786e9a83f5bf7a4de110.idx
.git/objects//11/d53c24bb5d2bf2e3f645ef188f8bc75fa9c911
.git/objects//45/fcb1dd311e5e45af759cb3627dca5f47f58f04
.git/objects//75/6c4879c0447db20980f73a26bc2ba072e08a6d
.git/objects//44/3f164cdde5059d78df6a61ca3f07bc6a605eb0
.git/objects//43/a1267370f1af98071d53f8508abbc56fa3abde
.git/objects//88/5588412d138cc89f06ffed5e83c316c2b593
.git/objects//5c/8aaa9f2a129d551b8cb2cb294676f63c4af410
.git/objects//65/e9e39935be8400ef12cc9003592f12244b50da
.git/objects//3a/cf0fb1c2febd24561294bfb966e1ad1f033eb8
.git/objects//98/96f7a7000a7b9d2fdb12047a141524358286c3
.git/objects//37/0e04baf4f62d1e62f4949208bc5e4d33af5336
.git/objects//6d/4dbd33860fce9c87bd3c4509def8cecb3f45
.git/objects//39/f1c5eabb1458fa6cf9042611599b69665cf288
.git/objects//55/56d17391aeee9b2b86d2821c011d7ed5377aa
.git/objects//b8/6eb90ba1ae5504edfc9ef8879e1c6d7a1b75
.git/objects//b6/2d570421c3096d8c80c7df56357cd3203fd3a
.git/objects//ea/c84c8320a3ab4f37a441a332b828c45ecedcc9
.git/objects//e1/82616690a91a8d0e363f4143e68dd9e136cce
.git/objects//e6/9de29bb2d1d6434b8b29ae775ad8c2e48c5391
.git/objects//8c/7cefb877c62a46a3b71c68a858c24075b379fe
.git/objects//76/8dec80c5e0734476d476ae83376c9c786b6450
.git/objects//2b/cb5d446129df427a1ce09e8ba658a5bb8ceca3
```

I am going to look at my alphabetically last object:

⚠ Warning

you cannot copy my path here, you have to use **your** last path

I copied the last line from my output above to make the next command.

```
cat .git/objects//2b/cb5d446129df427a1ce09e8ba658a5bb8ceca3
```

```
xx)JMU040g01????$??x^?}#}???}????kW?ch` `fb?????[]?°#o'??u?,o?[]??}?Ln?t)TQbR~i H?????[]?s+?g%??gF??0?.{
```

This looks like nonsense. That is because the object files are stored in a binary, not human-readable format. When we use cat, our terminal takes every 8 bits and turns it into an ascii character and that is what we see.

Question from class

Is that they are binary files why the files in git do not have extensions?

The answer is no. Actually *no* file strictly requires a file extension. file extensions are mostly for people

i Note

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Now, we can use `git cat-file` which is the first plumbing command we have seen so far to look at the git object associated with the the last hash in the list above.

Remember git commands that take a hash as input do not need the whole hash. They need at least 4 characters and enough to unique.

With the `-t` option `git cat-file` tells you the type of object.

```
git cat-file -t 2bcb
```

```
tree
```

Warning

at this point we all got different object types, (well out of the 3)

Then I looked at the *contents* of that same objects.

```
git cat-file -p 2bcb
```

```
040000 tree 95b60ce8cdec1bc4e1df1416e0c0e6ecbd3e7a8c .github
100644 blob b86eb90ba1ae5504edfcfdc9ef8879e1c6d7a1b75 README.md
100644 blob 443f164cdde5059d78df6a61ca3f07bc6a605eb0 about.md
```

Since mine is a tree we can see that it has a list of items and each item in the list includes:

- mode
- type (tree or blob)
- the hash
- the file name

Then for the README blob, I looked at the contents:

```
git cat-file -p b86e
```

```
# GitHub Practice
Name: Sarah Brown
[! [Open in Codespaces] (https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061)]
```

```
cat README.md
```

```
# GitHub Practice
```

```
Name: Sarah Brown
```

```
[![Open in Codespaces](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061
```

If I switch back to the main branch

```
git checkout main
```

```
Switched to branch 'main'  
Your branch is up to date with 'origin/main'.
```

Now it no longer matches:

```
cat README.md
```

```
# GitHub Practice
```

```
Name: Sarah Brown
```

```
[![Open in Codespaces](https://classroom.github.com/assets/launch-codespace-7f7980b617ed060a017424585567c4061  
age=35  
|file | contents |  
> | ++++++| +++++- |  
> | abstract_base_class.py | core abstract classes for the project |  
> | helper_functions.py | utilty funtions that are called by many classes |  
> | important_classes.py | classes that inherit from the abc |  
> | alternative_classes.py | classes that inherit from the abc |  
> | LICENSE.md | the info on how the code can be reused|  
> | CONTRIBUTING.md | instructions for how people can contribute to the project|  
> | setup.py | file with function with instructions for pip |  
> | tests_abc.py | tests for constructors and methods in abstract_base_class.py|  
> | tests_helpers.py | tests for constructors and methods in helper_functions.py|  
> | tests_imp.py | tests for constructors and methods in important_classes.py|  
> | tests_alt.py | tests for constructors and methods in alternative_classes.py|  
> | API.md | jupyterbook file to generate api documentation |  
> | _config.yml | jupyterbook config for documentation |  
> | _toc.yml | jupyter book toc file for documentation |  
> | philosophy.md | overview of how the code is organized for docs |  
> | example.md | myst notebook example of using the code |  
> | scratch.ipynb | jupyter notebook from dev |
```

! Important

If your object was a commit: look at the contents of the tree object after.

If your object was a blob, look at the type of the next one up in your find output until you find a tree or commit, then trace out one step like I did above.

8.12. Prepare for Next Class

[Skip to main content](#)

1. Review the notes from past classes
2. Think through and make some notes about what you have learned about design so far. Try to answer the questions below in `design_before.md`. If you do not now know how to answer any of the questions, write in what questions you have.

```
- What past experiences with making decisions about or studying design do you have?  
- What processes, decisions, and practices come to mind when you think about designing software?  
- From your experiences as a user you would describe the design of command line tools vs other GUI based too
```

8.13. Review today's class

1. Read about different workflows in git and describe which one you prefer to work with and why in `favorite_git_workflow.md` in your kwl repo. Two good places to read from are [Git Book](#) and the [atlassian Docs](#)
2. Update your kwl chart with what you have learned or new questions in the want to know column
3. In `commit_contents.md`, redirect the content of your most recent commit, its tree, and the contents of each tree and blob in that tree to the same file. Edit the file or use `echo` to put markdown headings between the different objects. Add a title `# Complete Commit` to the file and at the bottom of the file add `## Reflection` subheading with some notes on how, if at all this exercise helps you understand what a commit is.

8.14. More Practice

1. Read about different workflows in git and add responses to the below in a `workflows.md` in your kwl repo. Two good places to read from are [Git Book](#) and the [atlassian Docs](#)
2. Update your kwl chart with what you have learned or new questions in the want to know column
3. Find the hash of the blob object that contains the content of your `gitislike.md` file and put that in the comment of your badge PR for this badge.

```
## Workflow Reflection  
1. Why is it important that git can be used with different workflows?  
1. Which workflow do you think you would like to work with best and why?  
1. Describe a scenario that might make it better for the whole team to use a workflow other than the one you
```

8.15. Experience Report Evidence

Append the contents of one of your trees or commits and one blob or tree inside of that first one to the bottom of your experience report.

8.16. Questions After Today's Class

8.16.1. Are the contents of one item of a tree stored in key-value pairs or are they like a tuple of information?

A tree can be thought of like a list of tuples.

```
040000 tree 95b60ce8cdec1bc4e1df1416e0c0e6ecbd3e7a8c .github
100644 blob b86eb90ba1ae5504edfcde9ef8879e1c6d7a1b75 README.md
100644 blob 443f164cdde5059d78df6a61ca3f07bc6a605eb0 about.md
```

This tree has 3 items. Each item has a type of file (that number), a type of object, the hash of the object and the name of the content.

The 040000 type is for folder and 100644 is for a file.

8.16.2. How often does the ordinary developer need to use plumbing commands?

Only when you make a mistake, but they are really helpful for getting a better understanding.

8.16.3. Why do we need to know about our objects file?

Buliding up a better understanding of what git is, sets us up to study how it works in greater detail. This understanding helps you use git more effectively, both to not make mistakes as often and to fix them if you (or a coworker/team mate) still do make one.

8.16.4. Can the hashes be decoded?

No these are cryptographic hashes, so they are not reversible.

8.16.5. How to learn the commands?

Practice!

8.16.6. Why would anyone ever want to use a GUI once they learn Terminal commands? Would there still be benefits to a GUI?

Some tools have helpful utility and no command line interface to them. When using a touchscreen device?

Really, most people that get comfortable with a terminal, do use it a lot.

8.16.7. What command to find specific type, such as commits, or trees, or blobs?

You can get a list of all objects with `find` and then check the type.

You can also trace through following the pointers. So starting from `git log` to get the commit hashes, and then using one of those to get the tree, then the tree to get blobs.

8.16.8. What defines a VCS?

A version control system has to keep track of different versions of code in a systematic way. A more detailed answer for this is a good explore badge topic.

8.16.9. Does the commit hash account for just the email and time or does it use other data?

The commit hash is produced using the hashing function with the inputs:

- a header
- the tree
- the author with time stamp
- the committer with time stamp
- a blank line
- the commit message

8.16.10. What are the practical uses of finding the git object types for developers?

This is how you can trace out and manually recover something you thought was lost.

More importantly undersanding what happens under the hood prepares you to learn more advanced porcelain commands.

8.16.11. Will we see this in future classes?

Yes!

8.17. Questions Good for Explore badges

8.17.1. Version control systems generally

- What other version control systems are there besides git?
- what features do they have in common?

9. Why are these tools organized this way?

Today we're going to do a bit more practical stuff, but we are also going to start to get into the philosophy of how things are organized.

Understanding the context and principles will help you:

- remember how to do things
- form reliable hypotheses about how to fix problems you have not seen before
- help you understand when you should do things as they have always been done and when you should challenge and change things.

9.1. Admin

i Note

last class notes were posted and announced, but not linked

! Important

An issue or PR is always welcome and worth a community badge if I make a release and the website does not update

i Note

community badge opp

I used multiple cursors to type out that checklist by copying from the `_toc.yml` file and then editing each line to start `- [] fix` instead of `- file`

9.2. Why should we study design?

- it is easy to get distracted by implementation, syntax, algorithms
- but the core *principles* of design organize ideas into simpler rules

9.3. Why are we studying developer tools?

Recall:

The best way to learn design is to study examples [Schon1984, Petre2016], and some of the best examples of software design come from the tools programmers use in their own work.

Software design by example

note

- we will talk about some history in this course
- I will not take a “great men of history” approach

This is because:

- I think that history is important context for making decisions
- Many of these “great men” are actually, in many ways, Not Great™
- It *is* important to remember that all of this work was done by *people*
- all people are imperfect
- when people are deeply influential, ignoring their role in history is not effective, we cannot undo what they did
- we do not have to admire them or even say their names to acknowledge the work
- computing technology has been used in Very Bad ways and in Definitely Good ways

sources:

- wiki
- a free book
- composability over monolithic design
- social conventions

The tenets:

1. Make it easy to write, test, and run programs.
2. Interactive use instead of batch processing.
3. Economy and elegance of design due to size constraints ("salvation through suffering").
4. Self-supporting system: all Unix software is maintained under Unix.

For better or worse this is dominant, so understanding this is important.

Also, this critique is written that unix is not a good system for "normal folks" not in its effectiveness as a context for *developers* which is where *nix (unix, linux) systems remain popular.

"normal folks" is the author's term presumably attempting to describe a typical, nondeveloper computer user

If you have the  CLI installed and working locally, open the terminal that it works in and navigate to your KWL repo.

If you do not have that working locally, open a codespace on the main branch of your KWL repo

(I have it working locally and working locally lets me save my terminal output for the notes more easily)

cat the action file that posts your badges

```
cd Documents/inclass/systems/fa23-kwl-brownsarahm/
```

then check the repo's status

```
git status
```

```
on branch main
Your branch is up to date with 'origin/main'.

nothing to commit, working tree clean
```

```
cat .github/workflows/getassignment.yml
```

```
name: Create badge issues (Edit before Running)
on:
  workflow_dispatch

# once you edit, change the name

jobs:
  check-contents:
    runs-on: ubuntu-latest
```

[Skip to main content](#)

```

# Install dependencies
- name: Set up Python 3.9
  uses: actions/setup-python@v1
  with:
    python-version: 3.9

- name: Install Utils
  run: |
    pip install git+https://github.com/introcompsys/courseutils@main
- name: Get badge requirements
  run: |
    pretitle="prepare-$(date +"%Y-%m-%d")"
    sysgetassignment | gh issue create --title $prettitle --label prepare --body-file -
    rtitle="review-$(date +"%Y-%m-%d")"
    sysgetassignment --type review | gh issue create --title $rtitle --label review --body-file -
    pratitle="practice-$(date +"%Y-%m-%d")"
    sysgetassignment --type practice| gh issue create --title $pratitle --label practice --body-file -
  env:
    GH_TOKEN: ${{ secrets.GITHUB_TOKEN }}
# edit the run step above for the level(s) you want.
# You should keep the prepare, because they are required for experience badges
# You may choose to get only the review or only the practice (and change this any time)

```

gh

Work seamlessly with GitHub from the command line.

USAGE

`gh <command> <subcommand> [flags]`

CORE COMMANDS

auth:	Authenticate gh and git with GitHub
browse:	Open the repository in the browser
codespace:	Connect to and manage codespaces
gist:	Manage gists
issue:	Manage issues
org:	Manage organizations
pr:	Manage pull requests
project:	Work with GitHub Projects.
release:	Manage releases
repo:	Manage repositories

GITHUB ACTIONS COMMANDS

cache:	Manage Github Actions caches
run:	View details about workflow runs
workflow:	View details about GitHub Actions workflows

EXTENSION COMMANDS

classroom:	Extension classroom
------------	---------------------

ALIAS COMMANDS

co:	Alias for "pr checkout"
-----	-------------------------

ADDITIONAL COMMANDS

alias:	Create command shortcuts
api:	Make an authenticated GitHub API request
completion:	Generate shell completion scripts
config:	Manage configuration for gh
extension:	Manage gh extensions
gpg-key:	Manage GPG keys
label:	Manage labels
ruleset:	View info about repo rulesets
search:	Search for repositories, issues, and pull requests
secret:	Manage GitHub secrets
ssh-key:	Manage SSH keys
status:	Print information about relevant issues, pull requests, and notifications across repositories
variable:	Manage GitHub Actions variables

[Skip to main content](#)

```
actions: Learn about working with GitHub Actions
environment: Environment variables that can be used with gh
exit-codes: Exit codes used by gh
formatting: Formatting options for JSON data exported from gh
mintty: Information about using gh with MinTTY
reference: A comprehensive reference of all gh commands
```

FLAGS

```
--help Show help for command
--version Show gh version
```

EXAMPLES

```
$ gh issue create
$ gh repo clone cli/cli
$ gh pr checkout 321
```

LEARN MORE

```
Use 'gh <command> <subcommand> --help' for more information about a command.
Read the manual at https://cli.github.com/manual
```

gh

Work seamlessly with GitHub from the command line.

USAGE

```
gh <command> <subcommand> [flags]
```

CORE COMMANDS

```
auth: Authenticate gh and git with GitHub
browse: Open the repository in the browser
codespace: Connect to and manage codespaces
gist: Manage gists
issue: Manage issues
org: Manage organizations
pr: Manage pull requests
project: Work with GitHub Projects.
release: Manage releases
repo: Manage repositories
```

GITHUB ACTIONS COMMANDS

```
cache: Manage Github Actions caches
run: View details about workflow runs
workflow: View details about GitHub Actions workflows
```

EXTENSION COMMANDS

```
classroom: Extension classroom
```

ALIAS COMMANDS

```
co: Alias for "pr checkout"
```

ADDITIONAL COMMANDS

```
alias: Create command shortcuts
api: Make an authenticated GitHub API request
completion: Generate shell completion scripts
config: Manage configuration for gh
extension: Manage gh extensions
gpg-key: Manage GPG keys
label: Manage labels
ruleset: View info about repo rulesets
search: Search for repositories, issues, and pull requests
secret: Manage GitHub secrets
ssh-key: Manage SSH keys
status: Print information about relevant issues, pull requests, and notifications across repositories
variable: Manage GitHub Actions variables
```

HELP TOPICS

```
actions: Learn about working with GitHub Actions
environment: Environment variables that can be used with ah
```

[Skip to main content](#)

```
mintty:      Information about using gh with MinTTY
reference:   A comprehensive reference of all gh commands
```

FLAGS

```
--help      Show help for command
--version   Show gh version
```

EXAMPLES

```
$ gh issue create
$ gh repo clone cli/cli
$ gh pr checkout 321
```

LEARN MORE

```
Use 'gh <command> <subcommand> --help' for more information about a command.
Read the manual at https://cli.github.com/manual
```

```
cd fa23-kwl-brownsarahm/
```

```
-bash: cd: fa23-kwl-brownsarahm/: No such file or directory
```

```
pwd
```

```
/Users/brownsarahm/Documents/inclass/systems/fa23-kwl-brownsarahm
```

```
cat .github/workflows/getassignment.yml
```

```
name: Create badge issues (Edit before Running)
on:
  workflow_dispatch

# once you edit, change the name

jobs:
  check-contents:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v2

    # Install dependencies
    - name: Set up Python 3.9
      uses: actions/setup-python@v1
      with:
        python-version: 3.9

    - name: Install Utils
      run: |
        pip install git+https://github.com/introcompsys/courseutils@main

    - name: Get badge requirements
      run: |
        pretitle="$(date +"%Y-%m-%d")"
        sysgetassignment | gh issue create --title $pretitle --label prepare --body-file -
        rtitle="$(date +"%Y-%m-%d")"
        sysgetassignment --type review | gh issue create --title $rtitle --label review --body-file -
        pratitle="$(date +"%Y-%m-%d")"
        sysgetassignment --type practice| gh issue create --title $pratitle --label practice --body-file -
        env:
          GH_TOKEN: ${{ secrets.GITHUB_TOKEN }}

# edit the run step above for the level(s) you want.
# You should keep the prepare, because they are required for experience badges
#     You may choose to get only the review or only the practice (and change this any time)
```

[Skip to main content](#)

```
history | gh issue create --title example --body-file -
```

```
Creating issue in introcompsys/fa23-kwl-brownsarahm
```

```
https://github.com/introcompsys/fa23-kwl-brownsarahm/issues/32
```

We can use `gh` commands without an option to get the help for how to use them.

```
gh issue
```

Work with GitHub issues.

USAGE

```
gh issue <command> [flags]
```

GENERAL COMMANDS

```
create:      Create a new issue
list:        List issues in a repository
status:      Show status of relevant issues
```

TARGETED COMMANDS

```
close:       Close issue
comment:     Add a comment to an issue
delete:      Delete issue
develop:    Manage linked branches for an issue
edit:        Edit issues
lock:        Lock issue conversation
pin:         Pin a issue
reopen:     Reopen issue
transfer:   Transfer issue to another repository
unlock:     Unlock issue conversation
unpin:      Unpin a issue
view:       View an issue
```

FLAGS

```
-R, --repo [HOST/]OWNER/REPO  Select another repository using the [HOST/]OWNER/REPO format
```

INHERITED FLAGS

```
--help  Show help for command
```

ARGUMENTS

An issue can be supplied as argument in any of the following formats:
- by number, e.g. "123"; or
- by URL, e.g. "https://github.com/OWNER/REPO/issues/123".

EXAMPLES

```
$ gh issue list
$ gh issue create --label bug
$ gh issue view 123 --web
```

LEARN MORE

Use 'gh <command> <subcommand> --help' for more information about a command.
Read the manual at <https://cli.github.com/manual>

```
gh issue view
```

```
accepts 1 arg(s), received 0
```

```
example #32
Open • brownsarahm opened about 2 minutes ago • 0 comments

762 gh
763 gh
764 cd fa23-kwl-brownsarahm/
765 pwd
766 cat .github/workflows/getassignment.yml
767 history | gh issue create --title example --body-file -
```

View this issue on GitHub: <https://github.com/introcompsys/fa23-kwl-brownsarahm/issues/32>

We can see how this group of commands work with

```
gh issue
```

Work with GitHub issues.

USAGE

```
gh issue <command> [flags]
```

GENERAL COMMANDS

```
create:      Create a new issue
list:        List issues in a repository
status:      Show status of relevant issues
```

TARGETED COMMANDS

```
close:       Close issue
comment:     Add a comment to an issue
delete:      Delete issue
develop:    Manage linked branches for an issue
edit:        Edit issues
lock:        Lock issue conversation
pin:         Pin a issue
reopen:     Reopen issue
transfer:   Transfer issue to another repository
unlock:     Unlock issue conversation
unpin:      Unpin a issue
view:       View an issue
```

FLAGS

```
-R, --repo [HOST/]OWNER/REPO  Select another repository using the [HOST/]OWNER/REPO format
```

INHERITED FLAGS

```
--help  Show help for command
```

ARGUMENTS

An issue can be supplied as argument in any of the following formats:

- by number, e.g. "123"; or
- by URL, e.g. "<https://github.com/OWNER/REPO/issues/123>".

EXAMPLES

```
$ gh issue list
$ gh issue create --label bug
$ gh issue view 123 --web
```

LEARN MORE

Use 'gh <command> <subcommand> --help' for more information about a command.

Read the manual at <https://cli.github.com/manual>

```
gh issue close 32
```

```
cat .github/workflows/getassignment.yml
```

```
name: Create badge issues (Edit before Running)
on:
  workflow_dispatch

# once you edit, change the name

jobs:
  check-contents:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v2

    # Install dependencies
    - name: Set up Python 3.9
      uses: actions/setup-python@v1
      with:
        python-version: 3.9

    - name: Install Utils
      run: |
        pip install git+https://github.com/introcompsys/courseutils@main
    - name: Get badge requirements
      run: |
        pretitle="prepare-$(date +"%Y-%m-%d")"
        sysgetassignment | gh issue create --title $pretile --label prepare --body-file -
        rtitle="review-$(date +"%Y-%m-%d")"
        sysgetassignment --type review | gh issue create --title $rtitle --label review --body-file -
        pratitle="practice-$(date +"%Y-%m-%d")"
        sysgetassignment --type practice| gh issue create --title $pratitle --label practice --body-file -
    env:
      GH_TOKEN: ${{ secrets.GITHUB_TOKEN }}
    # edit the run step above for the level(s) you want.
    # You should keep the prepare, because they are required for experience badges
    #   You may choose to get only the review or only the practice (and change this any time)
```

```
gh issue list
```

```
Showing 28 of 28 open issues in introcompsys/fa23-kwl-brownsarahm
```

```
#31 practice-2023-10-04 practice about 1 day ago
#30 review-2023-10-04 review about 1 day ago
#29 prepare-2023-10-04 prepare about 1 day ago
#28 Lab 4 about 5 days ago
#27 practice-2023-09-29 practice about 5 days ago
#26 review-2023-09-29 review about 5 days ago
#25 prepare-2023-09-29 prepare about 5 days ago
#24 practice-2023-09-27 practice about 8 days ago
#23 review-2023-09-27 review about 8 days ago
#22 prepare-2023-09-27 prepare about 8 days ago
#21 Lab 3 about 12 days ago
#20 practice-2023-09-22 practice about 13 days ago
#19 review-2023-09-22 review about 13 days ago
#18 prepare-2023-09-22 prepare about 13 days ago
#17 practice-2023-09-20 practice about 15 days ago
#16 review-2023-09-20 review about 15 days ago
#15 prepare-2023-09-20 prepare about 15 days ago
#14 Lab 2 about 19 days ago
#13 practice-2023-09-15 practice about 20 days ago
#12 review-2023-09-15 review about 20 days ago
#11 prepare-2023-09-15 prepare about 20 days ago
#10 practice-2023-09-13 practice about 22 days ago
#9 review-2023-09-13 review about 22 days ago
```

[Skip to main content](#)

```
#6  review-2023-09-07    review  about 26 days ago  
#5  prepare-2023-09-08   prepare  about 26 days ago  
#4  Lab 1                Lab 1   about 26 days ago
```

! Important

This part did not happen in class due to time, but is still important.

We will see these commands again, but this reference will be useful in lab

9.4.1. Processing issues on the terminal

We can use a pipe to also get a count of the issues using the `wc` command which is for word count and its `-l` option to count lines instead.

```
gh issue list | wc -l
```

28

Or we can filter to get a subset of them using `grep` to filter. By default `grep` searches std in, so when we use it with a pipe it works well.

```
gh issue list | grep 'prepare'
```

```
29    OPEN    prepare-2023-10-04      prepare 2023-10-04 02:38:50 +0000 UTC  
25    OPEN    prepare-2023-09-29      prepare 2023-09-29 17:52:35 +0000 UTC  
22    OPEN    prepare-2023-09-27      prepare 2023-09-27 03:25:47 +0000 UTC  
18    OPEN    prepare-2023-09-22      prepare 2023-09-22 11:11:52 +0000 UTC  
15    OPEN    prepare-2023-09-20      prepare 2023-09-20 02:00:07 +0000 UTC  
11    OPEN    prepare-2023-09-15      prepare 2023-09-15 02:06:05 +0000 UTC  
 8    OPEN    prepare-2023-09-13      prepare 2023-09-13 01:42:24 +0000 UTC  
 5    OPEN    prepare-2023-09-08      prepare 2023-09-08 22:11:50 +0000 UTC
```

! Important

You should have fewer prepare than me, in this list because by default we only see the open ones

we can use `gh issue list --help` to see more options

List issues in a GitHub repository.

The search query syntax is documented here:

<<https://docs.github.com/en/search-github/searching-on-github/searching-issues-and-pull-requests>>

For more information about output formatting flags, see `gh help formatting`.

USAGE

`gh issue list [flags]`

FLAGS

`--app string` Filter by GitHub App author

[Skip to main content](#)

```
-q, --jq expression      Filter JSON output using a jq expression
--json fields           Output JSON with the specified fields
-l, --label strings     Filter by label
-L, --limit int         Maximum number of issues to fetch (default 30)
--mention string        Filter by mention
-m, --milestone string Filter by milestone number or title
-S, --search query      Search issues with query
-s, --state string      Filter by state: {open|closed|all} (default "open")
-t, --template string   Format JSON output using a Go template; see "gh help formatting"
-w, --web                List issues in the web browser
```

INHERITED FLAGS

```
--help                  Show help for command
-R, --repo [HOST/]OWNER/REPO Select another repository using the [HOST/]OWNER/REPO format
```

EXAMPLES

```
$ gh issue list --label "bug" --label "help wanted"
$ gh issue list --author monalisa
$ gh issue list --assignee "@me"
$ gh issue list --milestone "The big 1.0"
$ gh issue list --search "error no:assignee sort:created-asc"
```

LEARN MORE

```
Use 'gh <command> <subcommand> --help' for more information about a command.
Read the manual at https://cli.github.com/manual
```

and then we can use the `-s` flag set to all to see all to make yours match mine.

9.5. How do we Study (computer) Systems

When we think of something as a system, we can study it different ways:

- input/output behavior
- components
- abstraction layers

These basic ideas apply whether a computer system or not. We can probe things in different ways.

In a lot of disciplines people are taught one or the other, or they divide professionally into theorists or experimentalists along the lines.

People are the most effective at working with, within, and manipulating systems when they have multiple ways to achieve the same goal.

These are not mutually exclusive, we will use them all together and trade off.

When we study a system we can do so in two main ways. We can look at the input/output behavior of the system as a whole and we can look at the individual components. For each component, we can look at its behavior or the subcomponents. We can take what we know from all fo the components and piece that together. However, for a complex system, we cannot match individual components up to the high level behavior. This is true in both computers and other complex systems. In the first computers in the 1940s, the only things they did was arithmetic and you could match from their components al the way up pretty easily. Modern computers connect to the internet, send signals, load complex graphics, play sounds and many other things that are harder to decompose all at once. Outside of computers, scientists have a pretty good idea of how neurons work and that appears to be the same across mammals and other species (eg squid) but we do not understand how the whole brain of a mammal works, not even smaller mammals with less complex social lives than humans. Understanding the parts is not always enough to understand all of the complex ways the parts can work together. Computers are much less complicated than brains. They were made by brains.

But that fact motivates another way to study a complex system, across levels of abstraction. You can abstract away details and focus on one representation. This can be tied literally to components, but it can also be conceptual. For example, in CSC211 you use a model of stack and heap for memory. It's useful for understanding programming, but is not exactly what the hardware does. At times, it is even more useful though than understanding exactly what the hardware does. These abstractions also serve a social, practical purpose. In computing, and society at large really, we use *standards* these are sets of guidelines for how to build things. Like when you use a function, you need to know its API and what it is supposed to do in order to use it. The developers could change how it does that without impacting your program, as long as the API is not changed and the high level input/output behavior stays the same.

9.5.1. Behavior

Try something, see what happens

This is probably how you first learned to use a computer. Maybe a parent showed you how to do a few things, but then you probably tried other things. For most of you, this may have been when you were very young and much less afraid of breaking things. Over time you learned how to do things and what behaviors to expect. You also learned categories of things. Like once you learned one social media app and that others were also *social media* you then looked for similar features. Maybe you learned one video game had the option to save and expected it in the next one.

Video games and social media are *classes* or *categories* of software and each game and app are *instances*. Similarly, an Integrated Development Environment (IDE) is a category of software and VS Code, ... are instances. Also, version control is a category of software and git is an instance. A git host is also a category and GitHub is an instance. Just as before you were worried about details you transferred features from one instance to another within categories, I want you to think about what you know from one IDE and how that would help you learn another. We will study the actual features of IDE and what you might want to know about them so that you can choose your own. Becoming a more independent developer you'll start to have your own opinions about which one is better. Think about a person in your life who finds computers and technology overall intimidating or frustrating. They likely only use one social media app if at all, or maybe they only know to make documents in Microsoft word and they think that Google Docs is too much to learn, because they didn't transfer ideas from one to the other.

We have focused on the behavior of individual applications to this point, but there is also the overall behavior of the system in broad terms, typing on the keyboard we expect the characters to show (and when they don't for example in a shell password, we're surprised and concerned it is not working).

9.5.2. Components

Take it apart, assess the pieces

We have the high level parts: keyboard, mouse, monitor/screen, tower/computer. Inside we also tend to know there is a power supply, a motherboard, graphics card, memory, etc.

We can study how each of these parts works while not worrying about the others but having them there. This is probably how you learned to use a mouse. You focused your attention on the mouse and saw what else happened.

Or we can take an individual component and isolate it to study it alone. For a mouse this would be hard. Without a computer attached its output is not very visible. To do this, we would need additional tools to interpret its output and examine it. Most computer components actually would need additional tools to measure the electrical signals, but we could examine what happens

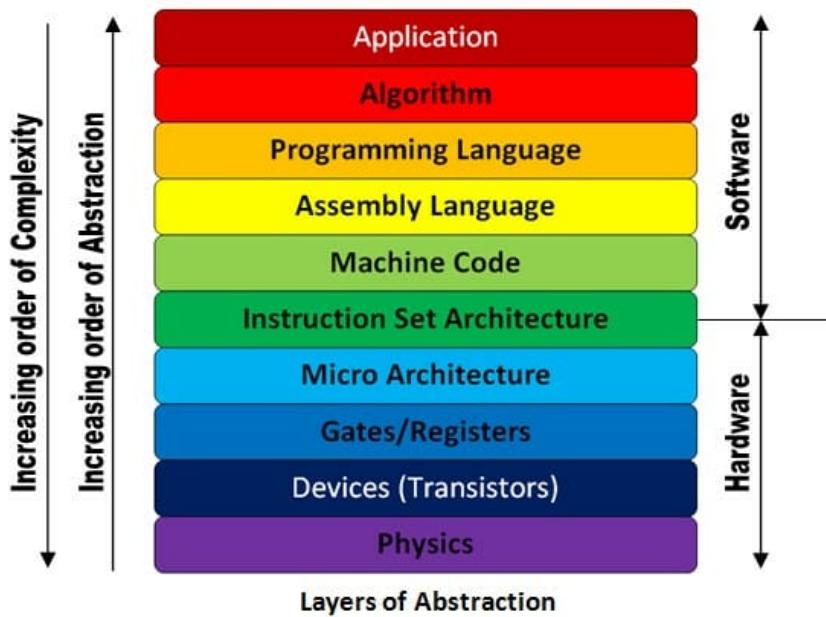
This idea, however that we can use another tool to understand each component is an important one. This is also a way to again, take care and study each piece even within a software-alone system without worrying about the hardware.

9.5.3. Abstraction

use a model

As we talked about the behavior and abstraction, we talked some about software and some about hardware. These are the two coarsest ways we can think about a computer system at different levels of abstraction. We can think about it only in physical terms and examine the patterns of electricity flow or we can think about only the software and not worry about the hardware, at a higher level of abstraction.

However, two levels is not really enough to understand how computer systems are designed.



- Application - the software you run.
- Algorithm - the way that it is implemented, in mathematical level
- Programming language - the way that it is implemented for a computer.
- Machine code translates to binary from assembly.

After the Programming language level, there is assembly. The advantage to assembly is that it is hardware independent and human readable. It is low level and limited to what the hardware *can* do, but it is a version of that that can be run on different hardware. It is much lower level. When you compile a program, it is translated to assembly. At this level, programs written in different level become indistinguishable. This has much lower level operations. We can do various calculations, but not things like compare. Things that were one step before, like assign become two, choose a memory location, then write to memory. This level of abstraction is the level of detail we will think about most. We'll look at the others, but spend much less time below here.

The instruction set architecture is, notice, where the line between software and hardware lives. This is because these are specific to the actual hardware, this is the level where there are different instructions if you have an Intel chip vs an Apple chip. This level reduces down the instructions even more specifically to the specifics things that an individual piece of hardware does and how they

The microarchitecture is the specific circuits: networks of smaller individual components. Again, we can treat the components as blocks and focus on how they work together. At this level we still have calculations like add, multiply, compare, negate, and we can store values and read them. That is all we have at this point though. At this level there are all binary numbers.

The actual gates (components that implement logical operations) and registers (components that hold values) break everything down to logical operations. Instead of adding, we have a series of `and`, `nand`, `or`, and `xor` put together over individual bits. Instead of numbers, we have `registers` that store individual zeros or ones. In a modern digital, electrical computer, at this level we have to actually watch the flow of electricity through the circuit and worry about things like the number of gates and whether or not the calculations finish at the same time or having other parts wait so that they are all working together. We will see later that when we try to allow multiple cores to work independently, we have to handle these timing issues at the higher levels as well. However, a register and gate can be implemented in different ways at the device level.

The device (or transistor in modern electrical digital computers) level, is where things transition between analog and digital. The world we live in is actually all analog. We just pay attention to lots of things at a time scale at which they appear to be digital. Over time devices have changed from mechanical switches to electronic transistors. Material science innovations at the physics level have improved the transistors further over time, allowing them to be smaller and more heat efficient. Because of abstraction, these changes could be plugged into new hardware without having to make any changes at any software levels. However, they do *enable* improvements at the higher levels.

9.6. Prepare for Next Class

note this is posted on 2023-10-05 because October 10th is a “Monday” for URI classes

1. Read the notes from October 5 and October 3. We will build on both of them on October 12. Make sure you have completed all of the steps in the github inclass repo from September too.
2. Start recording notes on *how* you use IDEs for the next couple of weeks using the template file below. We will come back to these notes in class later, but it is best to record over a time period instead of trying to remember at that time. Store your notes in your kwl repo in idethoughts.md on an `ide_prep` branch. **This is prep for much later, it does not go in the October 12 experience branch**

9.7. Review today's class

1. Read today's notes when they are posted.
2. Add to your software.md a section about if that project does or does not adhere to the unix philosophy.
3. create methods.md and answer the following:

- which of the three methods for studying a system do you use most often when debugging?
- do you think using a different strategy might help you debug faster sometimes? why or why not?

9.8. More Practice

1. Add to your software.md a section about if that project does or does not adhere to the unix philosophy and why. You can see what badge it was previously assigned in and the instructions on the KWL file list.
2. create methods.md and answer the following:

- do you think the ones you use most often are consistently effective? why or why not? When do they work or not?
- what are you most interested in trying that might be different?

9.9. Experience Report Evidence

Give examples of how you have used different ways of understanding things.

9.10. Questions After Today's Class

9.10.1. Why would we need to know about the lower layers of hardware and software if there are abstractions in place for us?

This is a great question!

Most of the time that is exactly the advantage to the abstractions, but you typically need to know about the things at least in the adjacent levels. Some times knowing about more layers can help you make better design choices or understand edge case behavior. We will see some of those through the rest of the semester.

Another part of why we teach these things in a CS degree is so that you can make a more informed choice about what you want to specialize in later, too.

9.10.2. what an example of Instruction set architecture

the x86 isa is an example.

9.10.3. How to install gh?

from their docs

9.10.4. How often do software engineers touch machine code?

Software engineers is a very broad category. If you write drivers, that might be very different than if you write front ends.

If you write compilers, again another very different amount.

9.10.5. how physics play into abstraction

The actual physics of how electricity works is the lowest level of abstraction, or most concrete/least abstract way to describe how a computer works.

9.10.6. why do brew and gh keep uninstalling from my terminal?

This might be a setting somewhere in your system that erases or resets things? If you find the answer to this and add it as an FAQ, that is worth a community badge.

9.10.7. Should I install the CLI?

You can, it's a little harder on Windows, but possible.

9.10.8. What is a GUI based tool?

GUI stands for graphical user interface. Everything on a modern computer except the terminal is a GUI.

9.10.9. Is it useful to create models during the process of development, or is it mostly useful after the fact?

Models are often made before things are built. Sometimes they are refined after, but usually they are used to guide the development.

9.10.10. How deep should we really understand abstraction layers and how useful is it as a developer to know it?

We will see them again and they will come up at least implicitly in other classes as well. It is important to know that they exist and what they are for sure. How much you directly interact with them will vary though.

9.10.11. How will our view on memory change with abstraction as we get to the higher level classes?

We will talk about the physical device that implements memory later and you will learn more about it again in 411 if you take that.

10. How does git create a commit?

Today we will dig into how git really works. This will be a deep dive and provide a lot of details about how git creates a commit. It will conceptually reinforce important concepts and practically give you some ideas about how you might fix things when things go wrong.

Later, we will build on this more on the practical side, but these **concepts** are very important for making sense of the more practical aspects of fixing things in git.

This deep dive in git is to help you build a correct, flexible understanding of git so that you can use it independently and efficiently. The plumbing commands do not need to be a part of your daily use of git, but they are the way that we can dig in and see what *actually* happens when git creates a commit.

Inspecting a system's components is a really good way to understand it and correctly understanding it will impact your ability to ask good questions and even look up the right thing to do when you need to fix things.

Also, looking at the parts of git is a good way to reinforce specific design patterns that are common in CS in a practical way. This means that today we will also:

- get more practice with bash
- see a practical example of hashing

10.1. Review to set the stage

Let's look at the github inclass repo.

```
cd Documents/inclass/systems/github-inclass-fa23-brownsarahm/
```

Recall: git stores important content in *files* that it uses like variables.

All of git's files, that it uses to perform the version control system actions are in the `.git` directory. Since this starts with a `.` it is "hidden" so to see it we use the `-a` option on `ls`.

```
ls -a
```

```
.
..
.git
.github
API.md
CONTRIBUTING.md
LICENSE.md
README.md
about.md
abstract_base_class.py
alternative_classes.py
docs
helper_functions.py
important_classes.py
setup.py
tests
```

Inside there we can see the files:

```
ls .git
```

```
COMMIT_EDITMSG  REBASE_HEAD      index          packed-refs
FETCH_HEAD      config           info           refs
HEAD           description       logs           objects
ORIG_HEAD       hooks
```

For example:

```
cat .git/HEAD
```

```
ref: refs/heads/main
```

holds the current branch and points to another file that holds the commit value

```
cat .git/refs/heads/main
```

```
042a42eb47c33ee43d793feb4d891a93e7460527
```

we also see the config file

```
cat .git/config
```

Recap!

[Skip to main content](#)

```
bare = false
logallrefupdates = true
ignorecase = true
precomposeunicode = true
[remote "origin"]
  url = https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
  fetch = +refs/heads/*:refs/remotes/origin/*
[branch "main"]
  remote = origin
  merge = refs/heads/main
[branch "1-create-an-about-file"]
  remote = origin
  merge = refs/heads/1-create-an-about-file
[branch "fun_fact"]
  remote = origin
  merge = refs/heads/fun_fact
```

that stores information about the different branches and remotes.

```
ls -a
```

```
.
..
.git
.github
API.md
CONTRIBUTING.md
LICENSE.md
README.md
about.md
abstract_base_class.py
alternative_classes.py
docs
helper_functions.py
important_classes.py
setup.py
tests
```

`.gitignore` is a file in the working directory that contains a list of files and patterns to not track.

```
cd ../tiny-book/
ls -a
```

```
.
..
.git
.gitignore
._build
._config.yml
._toc.yml
intro.md
logo.png
markdown-notebooks.md
markdown.md
notebooks.ipynb
references.bib
requirements.txt
```

```
cat .gitignore
```

```
._build/
```

Remember the `.gitignore` file lives **outside** of the `.git` directory because it is intended to be manually edited by the user, instead of written to by the `git` program.

10.2. Creating a repo from scratch

We will start in the top level course directory.

```
cd ..
```

[Skip to main content](#)

```
ls
```

```
fa23-kwl-brownsarahm      tiny-book
github-inclass-fa23-brownsarahm
```

Yours should also have your group repo, your messy folder, etc.

We can create an empty repo from scratch using `git init <path>`

Last time we used an existing directory like `git init .`

We will make a new directory for our repo:

```
git init test
```

```
hint: Using 'master' as the name for the initial branch. This default branch name
hint: is subject to change. To configure the initial branch name to use in all
hint: of your new repositories, which will suppress this warning, call:
hint:
hint:   git config --global init.defaultBranch <name>
hint:
hint: Names commonly chosen instead of 'master' are 'main', 'trunk' and
hint: 'development'. The just-created branch can be renamed via this command:
hint:
hint:   git branch -m <name>
Initialized empty Git repository in /Users/brownsarahm/Documents/inclass/systems/test/.git/
```

We can see what happened:

```
ls
```

```
fa23-kwl-brownsarahm      test
github-inclass-fa23-brownsarahm tiny-book
```

we see the new directory

then we can enter it

```
cd test/
```

and then rename the branch

```
git branch -m main
```

As usual, we will look at the status

```
git status
```

[Skip to main content](#)

i Not

we ge
conte

```
No commits yet  
nothing to commit (create/copy files and use "git add" to track)
```

Notice that there are no commits, and no origin.

```
ls .git
```

HEAD	description	info	refs
config	hooks	objects	

10.3. Searching the file system

We can use the bash command `find` to search the file system note that this does not search the **contents** of the files, just the names.

```
find .git/objects/
```

```
.git/objects/  
.git/objects//pack  
.git/objects//info
```

we have a few items in that directory and the directory itself.

We can limit by type, to only files with the `-type` option set to `f`

```
find .git/objects/ -type f
```

And we have no results. We have no objects yet. Because this is an empty repo

10.4. Creating Git Blob Objects Directly

There are 3 types:

- blob objects: the content of your files (data)
- tree objects: stores file names and groups files together (organization)
- Commit Objects: stores information about the sha values of the snapshots

```
classDiagram class tree{ List< - hash: blob - string: type - string:file name >} class commit{ hash: parent hash: tree string: message string: author string: time } class blob{ binary: contents } class object{ hash: name } object <|-- blob object <|-- tree object <|-- commit
```

All git objects are files stored with the name that is the hash of the content in the file

Let's create our first git object. git uses hashes as the key. We give the hashing function some content, it applies the algorithm and returns us the hash as the reference to that object. We can also write to our .git directory with this.

The `git hash-object` function works on files, but we do not have any files yet. We can create a file, but we do not have to. Remememer, **everything** is a file.

We can put content into the stdout file with `echo`

```
echo "test content"
```

```
test content
```

which shows on our terminal. We can us a pipe to connect the stdout of on command to the stdin of the next.

and we can use a pipe to connect std out of one command to stdin of the next command. Then we can use the `--stdin` option to tell git hash-object to read from there.

```
echo "test content" | git hash-object -w --stdin
```

We can break down this command:

- `git hash-object` would take the content you handed to it and merely return the unique key
- `-w` option tells the command to also write that object to the database
- `--stdin` option tells git hash-object to get the content to be processed from stdin instead of a file
- the `|` is called a pipe (what we saw before was a redirect) it pipes a *process output* into the next command
- `echo` would write to stdout, withthe pip it passes that to std in of the `git-hash`

```
d670460b4b4aece5915caf5c68d12f560a9fe3e4
```

and we can check if it wrote to the directory.

```
find .git/objects/ -type f
```

```
.git/objects//d6/70460b4b4aece5915caf5c68d12f560a9fe3e4
```

and we see a file that it was supposed to have!

This file contains binary content that is hard to read. Fortunately, git provides a utility. We can use `cat-file` to use the object by referencing at least 4 characters that are unique from the full hash, not the file name.

`cat-file` requires *an* option, we have used 2 so far:

- `-p` is for pretty print
- `-t` is for type

We can then view the type of this object

```
git cat-file -t d670
```

! Imp

pipes
we're
uses,
Pipes
comm

and its actual content

```
git cat-file -p d670
```

```
test content
```

This is the content that we put in, as expected.

10.4.1. Hashing a file

To hash content that corresponds to a file, we have to have a file first. We can use a redirect `>` to send content from echo to a different file.

```
echo "version 1" > test.txt
```

and store it, by hashing it

```
git hash-object -w test.txt
```

```
83baae61804e65cc73a7201a7252750c76066a30
```

we can look at what we have.

```
find .git/objects/ -type f
```

```
.git/objects//d6/70460b4b4aece5915caf5c68d12f560a9fe3e4  
.git/objects//83/baae61804e65cc73a7201a7252750c76066a30
```

Now this is the status of our repo.

```
classDiagram class d67046{ + "test content" +(blob) } class 83baae{ + Version 1 + (blob) }
```

We can check the type of files with `-t` and `git cat-file`

```
git cat-file -t 83ba
```

```
blob
```

```
git cat-file -t d670
```

```
blob
```

```
git status
```

```
On branch main  
No commits yet  
Untracked files:  
  (use "git add <file>..." to include in what will be committed)  
    test.txt  
nothing added to commit but untracked files present (use "git add" to track)
```

So far, even though we have hashed the object, git still thinks the file is untracked, because it is not in the tree and there are no commits that point to that part of the tree.

the working directory and the git repo are not strictly the same thing, and can be different like this. Mostly they will stay in closer relationship than we currently have unless we use plumbing commands, but it is good to build a solid understanding of how the `.git` directory relates to your working directory.

Notice, that we only have one file in the working directory.

```
ls
```

```
test.txt
```

10.5. Writing a tree

We can write a tree with the `write-tree` command

```
git write-tree
```

```
4b825dc642cb6eb9a060e54bf8d69288fbee4904
```

we can see the object exists

```
find .git/objects/ -type f
```

```
.git/objects//d6/70460b4b4aece5915caf5c68d12f560a9fe3e4  
.git/objects//4b/825dc642cb6eb9a060e54bf8d69288fbee4904  
.git/objects//83/baae61804e65cc73a7201a7252750c76066a30
```

we can verify that it is a tree

```
git cat-file -t 4b82
```

^--

[Skip to main content](#)

and look at the tree contents

```
git cat-file -p 4b82
```

but it is empty.

We have a file that was created, `git write-tree` did something but we told it to write a file without putting anything in the index, or staging area, that it reads from.

```
classDiagram class d67046{ +"test content" +(blob) } class 83baae{ +Version 1 +(blob) } class 4b825d{ +(tree) }
```

Now, we can add our file and its hashed object as it is to the index.

```
git update-index --add --cacheinfo 100644 \
83baae61804e65cc73a7201a7252750c76066a30 test.txt
```

the `\` lets us wrap onto a second line.

- this the plumbing command `git update-index` updates (or in this case creates an index, the staging area of our repository)
- the `--add` option is because the file doesn't yet exist in our staging area (we don't even have a staging area set up yet)
- `--cacheinfo` because the file we're adding isn't in your directory but is in the database.
- in this case, we're specifying a mode of 100644, which means it's a normal file.
- then the hash object we want to add to the index (the content) in our case, we want the hash of the first version of the file, not the most recent one.
- finally the file name of that content

10.6. A staging and snapshot edge case

Let's check git status again:

```
git status
```

```
On branch main
No commits yet
Changes to be committed:
  (use "git rm --cached <file>..." to unstage)
    new file:   test.txt
```

Now the file is staged.

Let's edit it further.

```
echo "version 2" >> test.txt
```

So the file has two lines

```
version 1  
version 2
```

Now check status again.

```
git status
```

```
On branch main  
No commits yet  
  
Changes to be committed:  
  (use "git rm --cached <file>..." to unstage)  
    new file: test.txt  
  
Changes not staged for commit:  
  (use "git add <file>..." to update what will be committed)  
  (use "git restore <file>..." to discard changes in working directory)  
    modified: test.txt
```

We added the first version of the file to the staging area, so that version is ready to commit but we have changed the version in our working directory relative to the version from the hash object that we put in the staging area so we *also* have changes not staged.

We can hash and store this version too.

```
git hash-object -w test.txt
```

```
0c1e7391ca4e59584f8b773ecdbbb9467eba1547
```

and verify a new object was created?

```
find .git/objects/ -type f
```

```
.git/objects//0c/1e7391ca4e59584f8b773ecdbbb9467eba1547  
.git/objects//d6/70460b4b4aece5915caf5c68d12f560a9fe3e4  
.git/objects//4b/825dc642cb6eb9a060e54bf8d69288fbee4904  
.git/objects//83/baae61804e65cc73a7201a7252750c76066a30
```

visually we now have 4 objects:

- plain content
- 2 versions of the file
- an empty tree

```
classDiagram class d67046{ +"test content" +(blob) } class 83baae{ +Version 1 +(blob) } class 4b825d{ +(tree) } class 0c1e73{  
+Version 1 +Verson 2 +(blob) }
```

Again, let's check in

```
git status
```

[Skip to main content](#)

```
on branch main
No commits yet
Changes to be committed:
  (use "git rm --cached <file>..." to unstage)
    new file:  test.txt

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:  test.txt
```

Hashing the content does not change the status here at all, because `git status` only traces from the `HEAD` pointer, compares that commit's tree to the index and the current working directory. We have no commits still and the index has not changed by hashing the content and creating a blob for it.

10.7. Writing a tree

Now we can write a tree and it will have content.

```
git write-tree
```

```
d8329fc1cc938780ffdd9f94e0d364e0ea74f579
```

Lets examine the tree, first check the type

```
git cat-file -t d832
```

```
tree
```

and now we can look at its contents

```
git cat-file -p d832
```

```
100644 blob 83baae61804e65cc73a7201a7252750c76066a30      test.txt
```

it tells us the mode of the single file is a regular file, that it is a blob, the hash where the file's content is snapshotted and the file name.

```
classDiagram class d67046{ +"test content" +(blob) } class 83baae{ +Version 1 +(blob) } class 4b825d{ +(tree) } class d8329f{ +blob: 83baae +filename: test.txt +(tree) } class 0c1e73{ +Version 1 +Verson 2 +(blob) } d8329f --> 83baae
This only keeps track of the objects, there are also still the HEAD that we have not dealt with and the index.
```

Now two of our objects are linked! the tree points to the blob of the first version of the file. We are getting closer to what would happen when we make a commit with a porcelain command.

```
git status
```

[Skip to main content](#)

```
on branch main
No commits yet
changes to be committed:
(use "git rm --cached <file>..." to unstage)
  new file: test.txt

changes not staged for commit:
(use "git add <file>..." to update what will be committed)
(use "git restore <file>..." to discard changes in working directory)
  modified: test.txt
```

10.8. Creating a commit manually

We can echo a commit message through a pipe into the commit-tree plumbing function to commit a particular hashed object.

```
echo "first commit" | git commit-tree d8329
```

```
0ec6f39c964a3149d426ae45bef4385e14444b2c
```

and we get back a hash. But notice that this hash is unique for each of us. Because the commit has information about the time stamp and our user.

The above hash is the one I got during class, but if I rerun I will get a different hash even though I have the same name and e-mail because the time changed.

! Important

You can find the hash of your commit object later by comparing to mine and getting the one that is unique or by checking the type of all of your objects until you find the one that is a commit.

We can also look at its type

```
git cat-file -t 0ec6
```

```
commit
```

and we can look at the content

```
git cat-file -p 0ec6
```

```
tree d8329fc1cc938780ffdd9f94e0d364e0ea74f579
author Sarah M Brown <brownsarahm@uri.edu> 1697131751 -0400
committer Sarah M Brown <brownsarahm@uri.edu> 1697131751 -0400

first commit
```

Now we check the final status of our repo

[Skip to main content](#)

```
git status
```

```
On branch main  
No commits yet  
Changes to be committed:  
(use "git rm --cached <file>..." to unstage)  
  new file: test.txt  
  
changes not staged for commit:  
(use "git add <file>..." to update what will be committed)  
(use "git restore <file>..." to discard changes in working directory)  
  modified: test.txt
```

we see it is “on main” this is because we set the branch to main , but since we have not written there, we have to do it directly. Notice that when we use the porcelain command for commit, it does this automatically; the porcelain commands do many things.

! Important

Check that you also have 6 objects and 5 of them should match mine, the one you should not have is the `0ec6f` one but you should have a different hash for your commit.

```
classDiagram class d67046{ +test content +(blob) } class 83baae{ +Version 1 +(blob) } class 4b825d{ +(tree) } class d8329f{ +blob:  
83baae +filename: test.txt +(tree) } class 0c1e73{ +Version 1 +Version 2 +(blob) } class 0ec6f{ +tree d8329f +author name +commit  
time } d8329f --> 83baae 0ec6f --> d8329f
```

It still says no commits, even though we just verified that it has one.

10.9. Git references

Remember git status compares the working directory to the current state of the active branch

- we can see the working directory with: `ls`
- we can see the active branch in the `HEAD` file
- what is its status?

Notice, git said we have no commits yet even though we have written a commit.

In our case because we made the commit manually, we did not update the branch.

This is because the main branch does not *point* to any commit.

We can verify by looking at the `HEAD` file

```
cat .git/HEAD
```

```
ref: refs/heads/main
```

and see that:

[Skip to main content](#)

```
cat .git/refs/heads/main
```

```
cat: .git/refs/heads/main: No such file or directory
```

which does not even exist!

we can see the objects though:

```
find .git/objects/ -type f
```

```
.git/objects//0c/1e7391ca4e59584f8b773ecdbbb9467eba1547  
.git/objects//0e/c6f39c964a3149d426ae45bef4385e14444b2c  
.git/objects//d6/70460b4b4ace5915caf5c68d12f560a9fe3e4  
.git/objects//d8/329fc1cc938780ffdd9f94e0d364e0ea74f579  
.git/objects//4b/825dc642cb6eb9a060e54bf8d69288fbee4904  
.git/objects//83/baae61804e65cc73a7201a7252750c76066a30
```

and we can create that file by putting the full hash of the commit into the file

```
echo 0ec6f39c964a3149d426ae45bef4385e14444b2c > .git/refs/heads/main
```

so that

```
cat .git/refs/heads/main
```

shows the hash:

```
0ec6f39c964a3149d426ae45bef4385e14444b2c
```

Now we check status and we are all set!

```
git status
```

```
On branch main
Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
    (use "git restore <file>..." to discard changes in working directory)
      modified:   test.txt

no changes added to commit (use "git add" and/or "git commit -a")
```

10.10. Prepare for Next Class

1. Read the notes from October 12. We will build on these directly in the future. **You need to have the `test` repo with the same status for lab on 10/13 and class on 10/17** Make sure you have completed all of the steps in the github inclass repo from September too.

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2. Start recording notes on *how* you use IDEs for the next couple of weeks using the template file below. We will come back to these notes in class later, but it is best to record over a time period instead of trying to remember at that time. Record which IDE(s) you use, what tasks you do, what features you use, what extensions, etc. Store your notes in your kwl repo in idethoughts.md on an `ide_prep` branch. **This is prep for much later, it does not go in the October 17 experience badge branch**

10.11. Review today's class

1. Make a table in gitplumbingreview.md in your KWL repo that relates the two types of git commands we have seen: plumbing and porcelain. The table should have two columns, one for each type of command. Each row should have one git plumbing command and at least one of the corresponding git porcelain command(s). Include two rows: `add` and `commit`.
2. Contribute to your group repo and review a classmate's contribution. Include a link to your contribution and review in your badge PR comment using markdown link syntax. Your contribution can be a short how to with a code excerpt or a resource. Include a link to your contribution and review in your badge PR comment using markdown link syntax:

```
[text to display](url/of/link)
```

10.12. More Practice

2. Read more details about [git internals](#) to review what we did in class in greater detail. Make a file gitplumbingdetail.md and create a visualization that is compatible with version control (eg can be viewed in plain text and compared line by line, such as table or mermaid graph) that shows the relationship between at least three porcelain commands and their corresponding plumbing commands.
3. Create gitislike.md and explain main git operations we have seen (add, commit, push) in your own words in a way that will either help you remember or how you would explain it to someone else at a high level. This might be analogies or explanations using other programming concepts or concepts from a hobby.
4. Contribute to your group repo and review a classmate's contribution. Include a link to your contribution and review in your badge PR comment using markdown link syntax. Your contribution can be a short how to with a code excerpt or a resource. (view the raw version of this issue page for the git internals link above for an example)

10.13. Experience Report Evidence

Put your list of objects in your `test` repo into a file `test_repo_objects.txt` in your Experience report branch.

10.14. Questions After Today's Class

10.14.1. Can a pointer to an old file exist as an object in the git objects?

a tree will have a pointer to the previous version of the file yes.

10.14.2. Is there a manual way to do other commands like git push and git add?

10.14.3. Why you are allowed to create empty trees if it is basically a wasted file?

Because it does not hurt anything.

10.14.4. How are pipes and redirect different?

Pipes connect stdout to stdin, to connect commands. Redirect just changes the source.

10.14.5. When do people manually create git objects and commits?

Manually exploring is not a common scenario. These commands exist primarily for git itself, remember modular code gives more power.

We went through doing it manually to see and understand. You can end up in edge case scenarios in other ways, but using the plumbing commands is the best way to see that.

10.14.6. Why are these commands so easy to confuse and mix up with each other? I have a hard time remembering some of the longer commands.

Some of the commands we have used are detailed low frequency use commands that you do not need to memorize.

10.14.7. Is there a quicker way to find the object type if you get lost. Instead of going through each of them with the “git cat-file -t” command?

For this activity, you can compare to mine. In a normal use scenario, you would not do this manually, so you would have some other way to know what commit or object you were looking for.

10.14.8. what are hashes?

A hash is a fixed length representation of variable length input. We will see more about them in the coming weeks.

10.14.9. What are trees?

Trees are one type of git object, that contains information about the directory at a given moment. It contains pointers to the blob objects and information about each file.

10.14.10. How do I change my inclass branch from master to main??

```
git branch -m main
```

10.14.11. What is the difference between the -t and -p flags? I noticed them while going through the commands.

10.14.12. Would there be any reason to use these commands rather than relying on the porcelain commands?

Not if things are going well, but they could be used to try to figure out what went wrong if you find a repo in a weird state.

10.14.13. When would we use this over doing it on GitHub itself aside from offline?

We cannot run these detailed steps on GitHub in browser. Recall, we do not even directly “add” files there. In browser, we have to commit in order to save a file.

10.14.14. Why does the file still have untracked changes?

We hashed the file, but did not put the second hash into the tree or create a second commit.

11. What is a commit number?

11.1. Announcements

! Important

Follow the prepare for 10/19 to get announcements from the repo commit messages

11.2. What is a hash?

A hash is:

- a fixed size value that can be used to represent data of arbitrary sizes
- the *output* of a hashing function
- often fixed to a hash table

Common examples of hashing are lookup tables and encryption with a cryptographic hash.

A hashing function could be really simple, to read off a hash table, or it can be more complex.

For example:

Hash	content
0	Success
1	Failure

If we want to represent the status of a program running it has two possible outcomes: success or failure. We can use the following hash table and a function that takes in the content and returns the corresponding hash. Then we could pass around the 0 and 1 as a single bit of information that corresponds to the outcomes.

In a more complex scenario, imagine trying to hash all of the new terms you learn in class.

A table would be hard for this, because until you have seen them all, you do not know how many there will be. A more effective way to hash this, is to derive a *hashing function* that is a general strategy.

A *cryptographic* hash is additionally:

- unique
- not reversible
- similar inputs hash to very different values so they appear uncorrelated

What are some ways a hash could be used?

Hashes can then be used for a lot of purposes:

- message integrity (when sending a message, the unhashed message and its hash are both sent; the message is real if the sent message can be hashed to produce the same hash)
- password verification (password selected by the user is hashed and the hash is stored; when attempting to login, the input is hashed and the hashes are compared)
- file or data identifier (eg in git)

11.3. Hashing in passwords

Passwords can be encrypted and the encrypted information is stored, then when you submit a candidate password it can compare the hash of the submitted password to the hash that was stored. Since the hashing function is nonreversible, they cannot see the password.

Some sites are negligent and store passwords unencrypted, if your browser warns you about such a site, proceed with caution and definitely do not reuse a password you ever use. (you *should* never reuse passwords, but especially do not if there is a warning)

An attacker who gets one of those databases, cannot actually read the passwords, but they could build a lookup table. For example, “password” is a bad password because it has been hashed in basically every algorithm and then the value of it can be reversed. Choosing an uncommon password makes it less likely that your password exists in a lookup table.

```
echo "password" | git hash-object --stdin
```

```
f3097ab13082b70f67202aab7dd9d1b35b7ceac2
```

11.4. Hashing in Git

In git we hash both the content directly to store it in the database (.git) directory and the commit information.

Recall, when we were working in our toy repo we created an empty repository and then added content directly, we all got the same hash, but when we used git commit our commits had different hashes because we have different names and made the commits at different seconds. We also saw that two entries were created in the `.git` directory for the commit.

This is a Secure Hashing Algorithm that is derived from cryptography. Because it is secure, no set of mathematical options can directly decrypt an SHA-1 hash. It is designed so that any possible content that we put in it returns a unique key. It uses a combination of bit level operations on the content to produce the unique values.

We can use the git hashing algorithm without writing to the repo too:

```
echo "what's up" | git hash-object --stdin
```

```
bd26a07a0f7b350d3bce48721cdc5a8c51f65306
```

```
echo "what's up " | git hash-object --stdin
```

```
1b0095f6628174ff6b4c9341e19230db33071fce
```

```
echo "what up " | git hash-object --stdin
```

```
d562044d1a61d1b86e3b15e70d6c7f5922e54498
```

```
echo "password" | git hash-object --stdin
```

```
f3097ab13082b70f67202aab7dd9d1b35b7ceac2
```

```
echo "passworksjfwklsjfd" | git hash-object --stdin
```

```
251c2d02f1fcbe5230648f4c386ba7d9afdd2cbe
```

```
echo "passworksjfwklsjfd" | git hash-object --stdin
```

```
251c2d02f1fcbe5230648f4c386ba7d9afdd2cbe
```

11.4.2. Git hashing algorithm

Git was originally designed to use SHA-1.

The SHA-1 Algorithm hashes content into a fixed length of 160 bits.

This means it can produce 2^{160} different hashes. Which makes the probability of a collision very low.

The number of randomly hashed objects needed to ensure a 50% probability of a single collision is

about 80. The formula for determining collision probability is $(n - 1)/n \cdot (1/n - 1)/(n - 1)$. $(1/2^{160}) \approx 80$

[Skip to main content](#)

i Note

I char
easie
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is 1.2×10^{24} or 1 million billion billion. That's 1,200 times the number of grains of sand on the earth.

—A SHORT NOTE ABOUT SHA-1 in the Git Documentation

git uses the SHA hash primarily for uniqueness, not privacy

It does provide some *security* assurances, because we can check the content against the hash to make sure it is what it matches.

Then the **SHA-1 collision attack** was discovered

Git switched to hardened HSA-1 in response to a collision.

In that case it adjusts the SHA-1 computation to result in a safe hash. This means that it will compute the regular SHA-1 hash for files without a collision attack, but produce a special hash for files with a collision attack, where both files will have a different unpredictable hash. [from](#).

they will change again soon

GitHub uses git, it is not an alternative implementation or a fork, so yes it will switch too. The developers at GitHub and other git hosts are among the most impacted by the change since they write code that directly interacts with git objects.

11.4.3. Remember we have many more git objects than commits

```
find github-inclass-fa23-brownsarahm/.git/objects -type f
```

```
github-inclass-fa23-brownsarahm/.git/objects/04/2a42eb47c33ee43d793feb4d891a93e7460527
github-inclass-fa23-brownsarahm/.git/objects/04/ab89e167ed77bc2a95710f69f68d91a6219471
github-inclass-fa23-brownsarahm/.git/objects/69/3a2b5b9ad4c27eb3b50571b3c93dde353320a1
github-inclass-fa23-brownsarahm/.git/objects/93/4c15dc2655c988c981d9a836783afebda77355
github-inclass-fa23-brownsarahm/.git/objects/5a/a1ed29b82e1cebb8527019b0e594ba71dda214
github-inclass-fa23-brownsarahm/.git/objects/5f/e5a9821625fad2cca4c500e497e6694132c303
github-inclass-fa23-brownsarahm/.git/objects/d7/6bc523443bda5a5daae2fe7fcfbf6fba71ae6d
github-inclass-fa23-brownsarahm/.git/objects/b3/78bd148e53dfa7195c58123362e40ae12ef3e7
github-inclass-fa23-brownsarahm/.git/objects/bc/281792d6ab62b153d7bf44f7985ec7fcfc3b850
github-inclass-fa23-brownsarahm/.git/objects/ca/eacb503cf4776f075b848f0faff535671f2887
github-inclass-fa23-brownsarahm/.git/objects/ca/feca302e31c65139b4a5294356e1ea8595dc1
github-inclass-fa23-brownsarahm/.git/objects/pack/8631fedd908bc07c0b64786e9a83f5bf7a4de110.rev
github-inclass-fa23-brownsarahm/.git/objects/pack/8631fedd908bc07c0b64786e9a83f5bf7a4de110.pack
github-inclass-fa23-brownsarahm/.git/objects/pack/8631fedd908bc07c0b64786e9a83f5bf7a4de110.idx
github-inclass-fa23-brownsarahm/.git/objects/11/d53c24bb5d2bf2e3f645ef188f8bc75fa9c911
github-inclass-fa23-brownsarahm/.git/objects/45/fcb1dd311e5e45af759cb3627dca5f47f58f04
github-inclass-fa23-brownsarahm/.git/objects/75/6c4879c0447db20980f73a26bc2ba072e08a6d
github-inclass-fa23-brownsarahm/.git/objects/44/3f164cdde5059d78df6a61ca3f07bc6a605eb0
github-inclass-fa23-brownsarahm/.git/objects/43/a1267370f1af98071d53f8508abbc56fa3abde
github-inclass-fa23-brownsarahm/.git/objects/88/5588412d138cce89f06ffed5e83c316c2b593
github-inclass-fa23-brownsarahm/.git/objects/5c/8aaa9f2a129d551b8cb2cb294676f63c4af410
github-inclass-fa23-brownsarahm/.git/objects/65/e9e39935be8400ef12cc9003592f12244b50da
github-inclass-fa23-brownsarahm/.git/objects/3a/cf0fb1c2feb24561294fb966e1ad1f033eb8
github-inclass-fa23-brownsarahm/.git/objects/98/96f7a7000a7b9d2fdb12047a141524358286c3
github-inclass-fa23-brownsarahm/.git/objects/37/0e04ba4f62d1e62f4949208bc5e4d33af5336
github-inclass-fa23-brownsarahm/.git/objects/6d/4dbd33860fcbe9c87bd3c4509def8cecb3f45
github-inclass-fa23-brownsarahm/.git/objects/39/f1c5eabb1458fa6cf9042611599b69665cf288
github-inclass-fa23-brownsarahm/.git/objects/55/56d17391aeeeec9b2b86d2821c011d7ed5377aa
github-inclass-fa23-brownsarahm/.git/objects/b8/6eb90ba1ae5504edfcfdc9ef8879e1c6d7a1b75
github-inclass-fa23-brownsarahm/.git/objects/b6/2d570421c3096d8c80c7df56357cdd3203fd3a
github-inclass-fa23-brownsarahm/.git/objects/ea/c84c8320a3ab4f37a441a332b828c45ecedcc9
```

```
github-inclass-fa23-brownsarahm/.git/objects/8c/7cefb877c62a46a3b71c68a858c24075b379fe  
github-inclass-fa23-brownsarahm/.git/objects/76/8dec80c5e0734476d476ae83376c9c786b6450  
github-inclass-fa23-brownsarahm/.git/objects/2b/cb5d446129df427a1ce09e8ba658a5bb8ceca3
```

```
echo "passworksjfwklsjfd" | git hash-object --stdin
```

```
251c2d02f1fcbe5230648f4c386ba7d9afdd2cbe
```

```
python
```

```
Python 3.11.4 (main, Jul 5 2023, 09:00:44) [Clang 14.0.6 ] on darwin  
Type "help", "copyright", "credits" or "license" for more information.  
>>> 16*16  
256  
>>> exit()
```

```
python
```

```
Python 3.11.4 (main, Jul 5 2023, 09:00:44) [Clang 14.0.6 ] on darwin  
Type "help", "copyright", "credits" or "license" for more information.  
>>> len('251c2d02f1fcbe5230648f4c386ba7d9afdd2cbe')  
40  
>>> exit()
```

11.4.4. Working with git hashes

Mostly, a shorter version of the commit is sufficient to be unique, so we can use those to refer to commits by just a few characters:

- minimum 4
- must be unique

Git log by default shows us the full length

```
cd github-inclass-fa23-brownsarahm/
```

```
git log
```

```
commit 042a42eb47c33ee43d793feb4d891a93e7460527 (HEAD -> main, origin/main, origin/HEAD)  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Thu Sep 21 13:26:59 2023 -0400  
  
begin organizing  
  
commit d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d  
Author: Sarah M Brown <brownsarahm@uri.edu>  
Date: Thu Sep 21 12:53:14 2023 -0400  
  
start organizng for real  
  
commit b0281702dc0b62b15ad7bf411f7005cc70f02b950
```

[Skip to main content](#)

```
Date: Thu Sep 21 12:51:22 2023 -0400
```

```
start organizing
```

```
commit 756c4879c0447db20980f73a26bc2ba072e08a6d (origin/fun_fact, fun_fact)
```

```
Author: Sarah M Brown <brownsarahm@uri.edu>
```

```
Date: Tue Sep 19 13:26:20 2023 -0400
```

```
second fun fact
```

```
commit 768dec80c5e0734476d476ae83376c9c786b6450
```

For most project 7 characters is enough and by default, git will give you 7 digits if you use `--abbrev-commit` and git will automatically use more if needed.

```
git log --abbrev-commit --pretty=oneline
```

```
042a42e (HEAD -> main, origin/main, origin/HEAD) begin organizing
d76bc52 start organizng for real
bc28179 start organizing
756c487 (origin/fun_fact, fun_fact) second fun fact
768dec8 Update about.md
6d4dbd3 add fun fact
5c8aaa9 Merge pull request #5 from introcompsys/add-name
65e9e39 (origin/add-name) closes #2
caeacb5 Merge pull request #4 from introcompsys/1-create-an-about-file
693a2b5 (origin/1-create-an-about-file, 1-create-an-about-file) create and complete about file closes #1
6a12db0 Add online IDE url
cfe32e5 Initial commit
```

```
git checkout bc28179
```

Note: switching to 'bc28179'.

You are in 'detached HEAD' state. You can look around, make experimental changes and commit them, and you can discard any commits you make in this state without impacting any branches by switching back to a branch.

If you want to create a new branch to retain commits you create, you may do so (now or later) by using -c with the switch command. Example:

```
git switch -c <new-branch-name>
```

Or undo this operation with:

```
git switch -
```

Turn off this advice by setting config variable advice.detachedHead to false

```
HEAD is now at bc28179 start organizing
```

Then we can check and the `HEAD` is moved to that commit

```
git log --abbrev-commit --pretty=oneline
```

```
bc28179 (HEAD) start organizing
756c487 (origin/fun_fact, fun_fact) second fun fact
768dec8 Update about.md
```

[Skip to main content](#)

```
65e9e39 (origin/add-name) closes #2
caeacb5 Merge pull request #4 from introcompsys/1-create-an-about-file
693a2b5 (origin/1-create-an-about-file, 1-create-an-about-file) create and complete about file closes #1
6a12db0 Add online IDE url
cfe32e5 Initial commit
```

```
git checkout main
```

```
Previous HEAD position was bc28179 start organizing
Switched to branch 'main'
Your branch is up to date with 'origin/main'.
```

```
git cat-file -p 6d4dbd3
```

```
tree 370e04baf4f62d1e62f4949208bc5e4d33af5336
parent 5c8aaa9f2a129d551b8cb2cb294676f63c4af410
author Sarah M Brown <brownsarahm@uri.edu> 1695143214 -0400
committer Sarah M Brown <brownsarahm@uri.edu> 1695143214 -0400

add fun fact
```

11.5. How do we get to the alphanumeric hashes we see?

Let's build this up with some review

11.5.1. What is a Number ?

a mathematical object used to count, measure and label

11.6. What is a number system?

While numbers represent **quantities** that conceptually, exist all over, the numbers themselves are a cultural artifact. For example, we all have a way to represent a single item, but that can look very different.

for example I could express the value of a single item in different ways:

- 1
- I

11.6.1. Hindu Arabic

In modern, western cultures, our number system is called the hindu-arabic system, it consists of a set of **numerals**: 0,1,2,3,4,5,6,7,8,9 and uses a **place based** system with **base 10**.

11.6.1.1. Where does the name come from?

- called “Arabic” numerals in the West because Arab merchants introduced them to Europeans
- slow adoption

11.6.1.2. Numerals

are the visual characters used to represent quantities

11.6.1.3. Place based

We use a **place based** system. That means that the position or place of the symbol changes its meaning. So 1, 10, and 100 are all different values. This system is also a decimal system, or base 10. So we refer to the places and the ones (10^0), the tens (10^1), the hundreds(10^2), etc for all powers of 10.

Number systems can use different characters, use different strategies for representing larger quantities, or both.

11.6.2. Roman Numerals

is a number system that uses different numerals and is not a place based system

There are symbols for specific values: I=1, V=5, X=10, L =50, C = 100, D=500, M = 1000.

Not all systems are place based, for example Roman numerals. In this system the subsequent symbols are either added or subtracted, with no (nonidentity) multipliers based on position. Instead if the symbol to right is the same or smaller, add the two together, if the left symbol is smaller, subtract it from the one on the right.

Then

- III = $1+1+1 = 3$
- IV = $-1 + 5 = 4$
- VI = $5+1 = 6$
- XLIX = $-10 + 50 -1 +10 = 49.$

This feel hard because it is unfamiliar

11.7. Different Bases

11.7.1. Decimal

To represent larger numbers than we have digits on we have a base (10) and then.

$$10 = 10 * 1 + 1 * 0$$

$$22 = 10 * 2 + 1 * 2$$

we have the ones (10^0)*place*, *tens*(10^1)*place*, *hundreds*(10^2) *place* etc.

11.7.2. Binary

Binary is any base two system, and it can be represented using any different characters.

Binary number systems have origins in ancient cultures:

- Egypt (fractions) 1200 BC
- China 9th century BC
- India 2nd century BC

In computer science we use binary because mechanical computers began using relays (open/closed) to implement logical (boolean) operations and then digital computers use on and off in their circuits.

We represent binary using the same hindu-arabic symbols that we use for other numbers, but only the 0 and 1(the first two). We also keep it as a place-based number system so the places are the ones(2^0), twos (2^1), fours (2^2), eights (2^3), etc for all powers of 2.

so in binary, the number of characters in the word binary is 110.

$$10 \Rightarrow 2 * 1 + 1 * 0 = 2$$

so this 10 in binary is 2 in decimal

$$1001 \Rightarrow 8 * 1 + 4 * 0 + 2 * 0 + 1 * 1 = 9$$

11.7.3. Octal

Is base 8. This too has history in other cultures, not only in computer science. It is rooted in cultures that counted using the spaces between fingers instead of counting using fingers.

This numbering system was popular in 6 bit and 12 bit computers, but is has origins before that. Native Americans using the Yuki Language (based in what is now California)used an octal system because they count using the spaces between fingers and speakers of the Pamean languages in Mexico count on knuckles in a closed fist. Europeans debated using decimal vs octal in the 1600-1800s for various reasons because 8 is better for math mostly. It is also found in Chinese texts dating to 1000BC.

$$10 \Rightarrow 8 * 1 + 1 * 0 = 8$$

so 10 in octal is 8 in decimal

$$401 \Rightarrow 64 * 4 + 8 * 0 + 1 * 1 = 257$$

As in binary we use hindu-arabic symbols, 0,1,2,3,4,5,6,7 (the first eight). Then nine is 11.

In computer science we use octal a lot because it reduces every 3 bits of a number in binary to a single character. So for a large number, in binary say **101110001100** we can change to **5614** which is easier to read, for a person.

11.7.4. Hexadecimal

This is commonly used for representing colors



This is how the git hash is 160 bits, or 20 bytes (one byte is 8 bits) but we represent it as 40 characters. $160/4=40$.

11.8. Prepare for Next Class

1. Review [the course website releases](#) to get familiar with what content appears there
2. Review the GitHub Action files in your KWL repo and make note of what if any syntax in there is unfamiliar. (note that link may not work on the rendered website, but will work on issues)
3. Use quote reply or edit to see how I made a relative path to a location within the repo in this issue.
4. Use [git log](#) to view recent updates to the course website from the [October 12 class](#) to the [October 17 class release](#)
5. review the open PR about a build badge if you are interested in that option and comment if anything is unclear or approve if it is helpful.

11.9. Review today's class

1. find 2 more real world examples of using other number systems (either different bases or different symbols and bases) that are current. Describe them in [numbers.md](#). Include links to your sources and be sure that the sources are trustworthy.
2. Calculate the maximum number of git objects that a repo can have without needing to use more than the minimum number of characters to refer to any object and include that number in gitcounts.md with a title [# Git counts](#). Describe the scenario that would get you to that number of objects with the maximum or minimum number of commits in terms of what types of objects would exist. Assume normal git use with porcelain commands, not atypical cases with plumbing commands. *If you get stuck, outline what you know and then request a review.*

11.10. More Practice

1. Read about the Learn more about the [SHA-1 collision attack](#)
2. Learn more about how git is working on changing from SHA-1 to SHA-256 and answer the transition questions below [gittransition.md](#)
3. find 2 more real world examples of using other number systems (either different bases or different symbols and bases) that are current. Describe them in [numbers.md](#)
4. Calculate the maximum number of git objects that a repo can have without needing to use more than the minimum number of characters to refer to any object and include that number in [gitcounts_scenarios.md](#) with a title [# Git counts](#). Describe 3 scenarios that would get you to that number of objects in terms of what types of objects would exist. For example, what is the maximum number of commits you could have without exceeding that number, how many files could you have? How could you get to that number of objects in the fewest number of commits? What might be a typical way to get there? Assume normal git use with porcelain commands, not atypical cases with plumbing commands. *If you get stuck, outline what you know and then request a review.*

11.11. gittransition

```
## transition questions
```

[Skip to main content](#)

2. What impact will the switch have on how git works?
3. Which developers will have the most work to do because of the switch?

11.12. Experience Report Evidence

none

11.13. Questions After Today's Class

11.13.1. What might the password table looklike?

You can check your own passwords against a collection of breech-revealed passwords, or download such a table at [haveibeenpwned](#)

Conceptually it could be as simmpel as 2 columns:

password	hash
...	...

11.13.2. Will we have to keep creating bigger and bigger number systems when computers get too fast at brute forcing hashes?

Most systems lock people out after a few tries to try to contol this, but potentially.

This is also why we typically have 2 factors now.

11.13.3. Are the letters used in hexadecimal representation global? Like if all countries that may not use english have to use the english characters in hex A,B,C,D,E,F?

The letters we use are not limited to English. The English alphabet descends largely from the latin alphabet, as do many other European languages. Further, since globalization, even some languages that historically had their own alphabets have adopted the English alphabet or one that is very similar.

Historically people may have used others for hex, but in programming contexts we all use the same latin alphabet .

11.13.4. Why are numbers so complicated?

Fundamentally, counting can happen in many different ways. What we talked about today is abstractions and representations that have been developed over 1000s of years over the entire planet.

People are complicated and vary a alot

11.13.5. What is the main difference between hash tables and hash functions?

A hash function tells how to produce the hash from the input. A hash table could assign hashes to content arbitrarily.

11.13.6. If the word “password” hash has been easily reversed, couldn’t that just be done with every word in a language?

Yes, it could, that is why we have rules about what makes a good password. That increases the possible options.

There are a lot of words in a language, but it’s a lot less than the total number of valid pass words, which do not have to be meaningful and typically can be any mix of letters in upper (26) or lower (+26) case, numbers (+10), or special characters (maybe another +20 or more). This means a password of length d can be $26 * 2 + 10 + 20 = 82^d$ options. Even for just length 2 there are then 6724 possible options. For length 4 there are over 45 million. So once you allow long passwords that are 30+ characters, it becomes really hard to store all of those options.

11.13.7. What exactly is a relay?

We will see this later when we talk more about hardware. It is an electrically operated switch.



the [wikipedia](#) article also has an animation

11.13.8. Are there any hashing algorithms that use numerical systems greater than base 16?

The hashing algorithm does not necessarily select a specific base. For example the SHA-1 algorithm is defined using a series of bitwise and mathematical operations on the binary representation of the content:

- split the messages into batches of length 512 bits
- break into 32 bit words
- xor
- and
- comparisons (if statements)
- bit shifts
- add
- or

you can see the [full psuedocode](#) for the algorithm

Any base can be used to write out the strings. 16 is the highest commonly used, but for example the [wikipedia](#) article on SHA-1 uses both base 64 and 16 in the examples

11.13.9. How would a developer create a function to hash passwords and store them securely?

In general, a developer would not develop a new hash function, you wouls use an existing one. Increasingly, authentication standards or using other authentication tools are common.

11.14. Questions that are a good explore badge

🔔 Where to collate these?

Ideas for where/how to collate questions like this are welcome and worth a community badge

11.14.1. What are good practices for adding authentication to my program?

This could be a good explore badge or potentially even a build on this topic

11.14.2. I want to learn more about encryption

If you make this a little more specific it could be a great explore badge. You could try out an encryption library or read and write a summary or something else that makes sense to you.

11.14.3. Hashing and Quantum computing

- Once quantum computing is more prominent, will hashing algorithms change because now it will can be both 0 and 1?
- Will current hashing algorithms be safe against quantum computing?

A good answer to this would rely on multiple sources and some independent reasoning.

🔔 Where to collate these

Ideas for where/how to collate questions like this are welcome and worth a community badge

12. Why did we learn the plumbing commands?

You will not typically use them on a day to day basis, but they are a good way to see what happens at the interim steps and make sure that you have the right understanding of what git does.

A **correct** understanding is essential for using more advanced features

While there is of course some content that we want you to know after this course, my goal is also to teach you process, by modeling it.

No one will every know all of the things but you can be fast or slow at finding answers.

And you can find correct answers, incorrect answers, or looks-okay-but-you-will-regret-this-later answers.

❗ Important

My goal is that you get good at *quickly* finding **correct** answers.

12.1 When is the blob created?

[Skip to main content](#)

First lets add some content to revise a file

```
echo "a sentence" >> about.md
```

and then use git status to check the repo

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   about.md

no changes added to commit (use "git add" and/or "git commit -a")
```

at this point file is changed, but it has only been changed in the working directory.

git does not run in the background automatically.

We can use `find` to inspect as we have, with `wc -l` to count the objects.

```
find .git/objects/ -type f | wc -l
```

36

we start with 36

Now we add the file to the staging area

```
git add .
```

and count the objects again

```
find .git/objects/ -type f | wc -l
```

37

and we see it increased. So the blob object is created when we stage the file.

This is how we can have a file that is both staged for commit and not staged for commit.

Right now we have a version of the file that has been previously hashed and committed at various times, and the version that is both edited locally *and* hashed and stored for a future commit.

Next we will edit the file again.

i Note

You can see here, it's important to understand the difference between the two stages.

```
echo "a sentence agian" >> about.md
```

and check the status again

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
    modified:   about.md

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   about.md
```

Now there are 3 versions of this file encountered by `git status` (active, there are actually more in past commits):

- the version in the last commit
- the version staged for commit
- the version in the working directory

12.2. How does git track file names?

Let's trace it out? First we will look at our recent commits

```
git log
```

```
commit 042a42eb47c33ee43d793feb4d891a93e7460527 (HEAD -> main, origin/main, origin/HEAD)
Author: Sarah M Brown <brownsarahm@uri.edu>
Date:   Thu Sep 21 13:26:59 2023 -0400

begin organizing

commit d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d
Author: Sarah M Brown <brownsarahm@uri.edu>
Date:   Thu Sep 21 12:53:14 2023 -0400

start organizng for real

commit bc281792d6ab62b153d7bf44f7985ec7cfcc3b850
Author: Sarah M Brown <brownsarahm@uri.edu>
Date:   Thu Sep 21 12:51:22 2023 -0400

start organizing

commit 756c4879c0447db20980f73a26bc2ba072e08a6d (origin/fun_fact, fun_fact)
Author: Sarah M Brown <brownsarahm@uri.edu>
Date:   Tue Sep 19 13:26:20 2023 -0400

second fun fact
```

Now we can use the first four characters (the minimum) or more if needed to be unique to look at that commit object

[Skip to main content](#)

```
git cat-file -p 042a
```

```
tree 11d53c24bb5d2bf2e3f645ef188f8bc75fa9c911  
parent d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d  
author Sarah M Brown <brownsarahm@uri.edu> 1695317219 -0400  
committer Sarah M Brown <brownsarahm@uri.edu> 1695317219 -0400  
  
begin organizing
```

Here, in the commit, we see that there are no file names. So we can keep tracing, we will look at the tree object from this commit.

```
git cat-file -p 11d
```

```
040000 tree 95b60ce8cdec1bc4e1df1416e0c0e6ecbd3e7a8c .github  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 API.md  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 CONTRIBUTING.md  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 LICENSE.md  
100644 blob 8c7cef8877c62a46a3b71c68a858c24075b379fe README.md  
100644 blob b62d570421c3096d8c80c7df56357cdd3203fd3a about.md  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 abstract_base_class.py  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 alternative_classes.py  
040000 tree 9896f7a7000a7b9d2fdb12047a141524358286c3 docs  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 helper_functions.py  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 important_classes.py  
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391 setup.py  
040000 tree 45fc1dd311e5e45af759cb3627dca5f47f58f04 tests
```

Here in the tree we see that each line includes the name from the working directory of the file that the blob came from or the folder that is represented by that additional tree.

Let's check a blob object for completeness.

```
git cat-file -p b62d
```

```
Sarah Brown  
2027  
- i skied competitively in high school  
- i started at URI in 2020  
- I went to Northeastern
```

Note here that there is no mention of the file name, the file name is **only** in the tree.

```
git status
```

```
On branch main  
Your branch is up to date with 'origin/main'.  
  
Changes to be committed:  
(use "git restore --staged <file>..." to unstage)  
modified:   about.md  
  
Changes not staged for commit:  
(use "git add <file>..." to update what will be committed)  
(use "git restore <file>..." to discard changes in working directory)
```

[Skip to main content](#)

12.3. What is the index?

The staging area/index

```
cat .git/index
```

```
fk#.github/workflows/create_issues.yml.e.???.m?0e.???.m?0??d????? ??CK?)?wZ??S?API.mde.???.Me.???.M??e???? ??CK' LICENSE.mde.???.t?e.???.t???g?????|?w?*F??h?X?@u?y? README.mde1[?5??e1[?5??o?8????0f?DTj0|????,?tabout.mdocs3 0
?????
{??/?z$5????tests4 0
E???1^E?u??b}?_G???.github1 1
??
????????>z?workflows1 0
nm?```
```



```
```{code-cell} bash
:tags: ["skip-execution"]
git cat-file -p .git/index
```

```
fatal: Not a valid object name .git/index
```

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

Changes to be committed:
 (use "git restore --staged <file>..." to unstage)
 modified: about.md

Changes not staged for commit:
 (use "git add <file>..." to update what will be committed)
 (use "git restore <file>..." to discard changes in working directory)
 modified: about.md
```

## 12.4. Why does it show the help

### ! Important

This was a real question from class and is a good question!

Most command line tools are designed to show you the help, not only an error when you use it incorrectly.

```
git stats
```

```
git: 'stats' is not a git command. See 'git --help'.
The most similar command is
 status
```

[Skip to main content](#)

## 12.5. Git References

### Note

I have commented out for now where the inspection of git tags did not go as expected. I hope to fill this in with the answer and notify you later.

## 12.6. Making a git tag

We will work in the github-inclass repo for this.

```
cd ../github-inclass-fa23-brownsarahm/
```

The `git tag` command works a lot like `git branch`. With no parameters it lists the current tags. With options it can also create or manage them.

```
git tag
```

If we provide a name for it, we can create a lightweight tag

```
git tag v1
```

A lightweight tag is just a pointer to a commit.

```
git tag
```

```
v1
```

We can see the tag is added to the annotation on the commits with git log.

```
git log --pretty=oneline
```

```
042a42eb47c33ee43d793feb4d891a93e7460527 (HEAD -> main, tag: v1, origin/main, origin/HEAD) begin organizing
d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d start organizng for real
bc281792d6ab62b153d7bf44f7985ec7cfc3b850 start organizing
756c4879c0447db20980f73a26bc2ba072e08a6d (origin/fun_fact, fun_fact) second fun fact
768dec80c5e0734476d476ae83376c9c786b6450 Update about.md
6d4dbd33860fce9c87bd3c4509deff8cecb3f45 add fun fact
5c8aaa9f2a129d551b8cb2cb294676f63c4af410 Merge pull request #5 from introcompsys/add-name
65e9e39935be8400ef12cc9003592f12244b50da (origin/add-name) closes #2
caeacb503cf4776f075b848f0faff535671f2887 Merge pull request #4 from introcompsys/1-create-an-about-file
693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file) create and (
6a12db0035e7c73772f7b2348b80dd0bfb3a2a2e Add online IDE url
cfe32e5066921ad876d8a2c74b1fcbb00c99b1cc7 Initial commit
```

```
git tag --help
```

[Skip to main content](#)

```
git tag v0 65e9
```

and see it the same way.

```
git log --pretty=oneline
```

```
042a42eb47c33ee43d793feb4d891a93e7460527 (HEAD -> main, tag: v1, origin/main, origin/HEAD) begin organizing
d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d start organizng for real
bc281792d6ab62b153d7bf44f7985ec7cf3b850 start organizing
756c4879c0447db20980f73a26bc2ba072e08a6d (origin/fun_fact, fun_fact) second fun fact
768dec80c5e0734476d476ae83376c9c786b6450 Update about.md
6d4dbd33860fcceb9c87bd3c4509deff8cecb3f45 add fun fact
5c8aaa9f2a129d551b8cb2cb294676f63c4af410 Merge pull request #5 from introcompsys/add-name
65e9e39935be8400ef12cc9003592f12244b50da (tag: v0, origin/add-name) closes #2
caeacb503cf4776f075b848f0faaff535671f2887 Merge pull request #4 from introcompsys/1-create-an-about-file
693a2b5b9ad4c27eb3b50571b3c93dde353320a1 (origin/1-create-an-about-file, 1-create-an-about-file) create and c
6a12db0035e7c73772f7b2348b80dd0bfb3a2a2e Add online IDE url
cfe32e5066921ad876d8a2c74b1fc00c99b1cc7 Initial commit
```

These create files in the .git direcotry with the hash in them

```
ls .git/refs/tags/
```

```
v0 v1
```

```
cat .git/refs/tags/v0
```

```
65e9e39935be8400ef12cc9003592f12244b50da
```

Tags can be used with other git commands like `git log` to show only a subset of the commits.

```
git log --pretty=oneline v0..v1
```

```
042a42eb47c33ee43d793feb4d891a93e7460527 (HEAD -> main, tag: v1, origin/main, origin/HEAD) begin organizing
d76bc523443bda5a5daae2fe7fcfbf6fba71ae6d start organizng for real
bc281792d6ab62b153d7bf44f7985ec7cf3b850 start organizing
756c4879c0447db20980f73a26bc2ba072e08a6d (origin/fun_fact, fun_fact) second fun fact
768dec80c5e0734476d476ae83376c9c786b6450 Update about.md
6d4dbd33860fcceb9c87bd3c4509deff8cecb3f45 add fun fact
5c8aaa9f2a129d551b8cb2cb294676f63c4af410 Merge pull request #5 from introcompsys/add-name
```

#### **i Note**

I used that to generate a list of changes in the [class 11 release](#)

## 12.7. What if I have changes I do not want to lose or commit yet

[Skip to main content](#)

```
git push
```

```
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
! [rejected] main -> main (fetch first)
error: failed to push some refs to 'https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git'
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

because we have our local and remote main branches out of sync

```
git pull
```

```
remote: Enumerating objects: 9, done.
remote: Counting objects: 100% (9/9), done.
remote: Compressing objects: 100% (3/3), done.
remote: Total 6 (delta 3), reused 6 (delta 3), pack-reused 0
Unpacking objects: 100% (6/6), 745 bytes | 82.00 KiB/s, done.
From https://github.com/introcompsys/github-inclass-fa23-brownsarahm
 042a42e..4202c16 main -> origin/main
Updating 042a42e..4202c16
error: Your local changes to the following files would be overwritten by merge:
 about.md
Please commit your changes or stash them before you merge.
Aborting
```

Pulling did not work either.

However, technically the tags can be pushed anyway, even without pushing the rest of our files.

```
git push --tags
```

```
Total 0 (delta 0), reused 0 (delta 0), pack-reused 0
To https://github.com/introcompsys/github-inclass-fa23-brownsarahm.git
 * [new tag] v0 -> v0
 * [new tag] v1 -> v1
```

We can then see them in the browser:

```
gh repo view --web
```

```
Opening github.com/introcompsys/github-inclass-fa23-brownsarahm in your browser.
```

## 12.8. Using git to debug

### Note

I am going to revise this later to understand for now refer to the git hook chapter

[Skip to main content](#)

If you find a bug in your code and you do not know when it was introduced `git bisect` can help you perform a binary search over your commits to find the first commit that introduced the bug.

```
git bisect start
```

```
status: waiting for both good and bad commits
```

It takes 2 inputs as separate calls after you start it a known bad commit and a known good commit.

We will say that we know our current commit is bad.

```
git bisect bad
```

```
status: waiting for good commit(s), bad commit known
```

And that `v0` tag was good.

#### Note

This is a good use of tags!

```
git bisect good v0
```

```
Bisecting: 3 revisions left to test after this (roughly 2 steps)
error: Your local changes to the following files would be overwritten by checkout:
 about.md
Please commit your changes or stash them before you switch branches.
Aborting
```

Now that working directory update that we made comes back to get in the way.

We have the option to commit or stash.

## 12.9. What if I want to keep changes, but not commit them yet?

Stash creates git objects of content that you can recover later. It works like a first-in-first-out queue by default and is a conceptually separate set of content from the commit history (though it is still stored in the `.git/` directory)

```
git stash
```

```
Saved working directory and index state WIP on main: 042a42e begin organizing
```

once we stash it, our working directory is clean and we can go back to debugging

Now we can tell it the good commit again

```
git bisect good v0
```

```
Bisecting: 3 revisions left to test after this (roughly 2 steps)
[768dec80c5e0734476d476ae83376c9c786b6450] Update about.md
```

What git does here is checks out the commit in the middle of the commits we labeled good and bad, this allows us to check whatever we were looking for and then we have to label each commit it checks out for us as good or bad.

```
git bisect good
```

```
Bisecting: 1 revision left to test after this (roughly 1 step)
[bbc281792d6ab62b153d7bf44f7985ec7cf3b850] start organizing
```

If we say it is good, it takes the next commit to be halfway between this commit and the one labeled bad.

```
git bisect bad
```

```
Bisecting: 0 revisions left to test after this (roughly 0 steps)
[756c4879c0447db20980f73a26bc2ba072e08a6d] second fun fact
```

When we label a commit bad, it checks out the commit between the current commit and the closest one labeled good

Here we do whatever we need to do to figure out if the currently checked out version is good or bad.

And label this comit

```
git bisect bad
```

```
756c4879c0447db20980f73a26bc2ba072e08a6d is the first bad commit
commit 756c4879c0447db20980f73a26bc2ba072e08a6d
Author: Sarah M Brown <brownsarahm@uri.edu>
Date: Tue Sep 19 13:26:20 2023 -0400
```

second fun fact

```
about.md | 2 ++
1 file changed, 2 insertions(+)
```

In this case, once we label it bad, now git has enough information to tell us what commit was the first bad one and what changes were made in this commit.

This will help us decide how to fix it.

```
git status
```

```
(use "git bisect reset" to get back to the original branch)
nothing to commit, working tree clean
```

"detached" HEAD means that the head pointer is set to a specific commit rather than a branch.

When we are done, we can use reset to go back to main and then apply our fix.

```
git bisect reset
```

```
Previous HEAD position was 756c487 second fun fact
Switched to branch 'main'
Your branch is behind 'origin/main' by 2 commits, and can be fast-forwarded.
(use "git pull" to update your local branch)
```

## 12.11. What about the stashed content

Now that we are on main with a clean working directory it is a good time to pull the remote changes.

```
git pull
```

```
Updating 042a42e..4202c16
Fast-forward
 README.md | 37 ++++++-----
about.md => docs/about.md | 0
2 files changed, 19 insertions(+), 18 deletions(-)
rename about.md => docs/about.md (100%)
```

We can use `list` on `git stash` to see the stashed changes

```
git stash list
```

```
stash@{0}: WIP on main: 042a42e begin organizing
```

and then `apply` to apply them

```
git stash apply
```

```
On branch main
Your branch is up to date with 'origin/main'.

Changes not staged for commit:
(use "git add <file>..." to update what will be committed)
(use "git restore <file>..." to discard changes in working directory)
modified: docs/about.md

no changes added to commit (use "git add" and/or "git commit -a")
```

it updates the working directory but not the index by default.

[Skip to main content](#)

If we re stage the file

```
git add .
```

and and make more edits

```
echo "another edit" >> docs/about.md
```

so that we have both staged and unstaged changes again

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

Changes to be committed:
 (use "git restore --staged <file>..." to unstage)
 modified: docs/about.md

Changes not staged for commit:
 (use "git add <file>..." to update what will be committed)
 (use "git restore <file>..." to discard changes in working directory)
 modified: docs/about.md
```

and stash this status

```
git stash
```

```
Saved working directory and index state WIP on main: 4202c16 fix readme to remove >
```

```
git status
```

```
On branch main
Your branch is up to date with 'origin/main'.

nothing to commit, working tree clean
```

we now have 2 stashes

```
git stash list
```

```
stash@{0}: WIP on main: 4202c16 fix readme to remove >
stash@{1}: WIP on main: 042a42e begin organizing
```

we can apply the on in 0 to both the workign directory and the staging area with the `--index` option.

```
git stash apply --index
```

[Skip to main content](#)

```
on branch main
Your branch is up to date with 'origin/main'.

Changes to be committed:
 (use "git restore --staged <file>..." to unstage)
 modified: docs/about.md

Changes not staged for commit:
 (use "git add <file>..." to update what will be committed)
 (use "git restore <file>..." to discard changes in working directory)
 modified: docs/about.md
```

## 12.12. Prepare for Next Class

2. If you have not already or right before class, review the GitHub Action files in your KWL repo and make note of what if any syntax in there is unfamiliar. (note that link may not work on the rendered website, but will work on issues)
3. Use quote reply or edit to see how I made a relative path to a location within the repo in this issue.
4. Check out the [github action marketplace](#) to see other actions that are available and try to get a casual level of understanding of the types of things that people use actions for.

## 12.13. Review today's class

1. Use git bisect to find the first bad commit in the [toy bug repo](#), save the command history and the bad commit hash to `git_debug.md`
2. Create `tagtypeexplore.md` with the template below. Determine how many of the tags in the course website are annotated vs lightweight using `git cat-file` to inspect the tags and the `git tag` help to determine which tags are of each type.

```
Tags

<!-- short defintion/description in your own words of what a tag is and what it is for -->

Inspecting tags

Course website tags by type:
- annotated:
- lightweight:
```

## 12.14. More Practice

1. Use your [github-in-class](#) repo to create a scenario where you can fix a problem using a git command from the [patching or debugging section of the docs](#). Create a log of what you did using the history or git log into a file `gitstory.md`. If you have a project in another class or another badge in this class that causes you to use one in a real scenario, that can count. If not, for example, you could create a “bug” and then use bisect to find it.
2. Create `tagtypes.md` with the template below. Include an experiment that shows which if either type of tag creates a new git object. There are two types, try creating one of each a lightweight tag (provide only the tag name- what we did in class) and an annotated (provide a name and a message with `-m`). Determine many of the tags in the course website are annotated vs lightweight using what you learned about how tags are represented and `git cat-file` to see which is which.

```
Tags
```

[Skip to main content](#)

```
Comparing tag types
<!-- include your experiment terminal history and interpretation -->
Inspecting tags

Course website tags by type:
- annotated:
- lightweight:
```

## 12.15. Experience Report Evidence

save your command history to [2023-10-19-log.txt](#) and put that file in your KWL repo

## 12.16. Questions After Today's Class

### Note

due to scheduling issues this will be late today

# 13. How can I use bash to automate things?

## 13.1. What is bash again?

So far we have used bash commands to navigate our file system as a way to learn about the file system itself. To do this we used commands like:

- [mv](#)
- [cd](#)
- [pwd](#)
- [ls](#)

Bash is a unix shell for the GNU operating system and it has been adopted in other contexts as well. It is the default shell on Ubuntu linux as well for example (and many others). This is why we teach it.

We can describe this relationship with a concept map. Each shape corresponds to a *concept* and the arrows are labeled to describe the relationship between the two concepts. This can be a helpful way of writing out how you understand things.

flowchart TD; shell --> |is accessed through| terminal; terminal --> |is instance of| shell; zsh --> |is instance of| shell; git --> |is a program accessed through| shell

A Unix shell is both a command interpreter and a programming language. As a command interpreter, the shell provides the user interface to the rich set of GNU utilities. The programming language features allow these utilities to be combined.

Read the official definition of [bash](#) and a shell in [the bash manual](#)

We can add this information to the diagram:

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```
graph TD; shell --> terminal["is accessed through terminal"]; terminal --> bash["is instance of shell zsh"]; bash --> git["is instance of shell git"]; git --> program["is a program accessed though shell subgraph shell pl[programming language] i[command interpreter] end"]
```

## 13.2. What does this definition of bash mean?

Today we will start from the main course directory.

Note on macOS when I run `bash` to use the bash shell, it reminds me that MacOS prefers a different shell.

```
Last login: Sat Oct 21 17:29:01 on ttys080
The default interactive shell is now zsh.
To update your account to use zsh, please run `chsh -s /bin/zsh`.
For more details, please visit https://support.apple.com/kb/HT208050.
```

We can have different shells in the same terminal in some cases, and all of the different shells on the system have access to the same file system.

Then I will move to my systems dir

```
cd Documents/inclass/systems/
```

and look at files

```
ls
```

```
fa23-kwl-brownsarahm github-inclass-fa23-brownsarahm
fall2023 test
ghic tiny-book
```

## 13.3. Working from an Example

### Important

Here I used `cd fa23-kwl-brownsarahm` and `gh repo view --web` to go to my KWL repo in the browser and then `cd ..` to go back

In your KWL repo the `.github/workflows` directory has several `.yml` files that are github action files.

These files are yaml, with key:value pairs. The values of the `run` key are commands that are passed to bash. So these are a place where you can see examples of what I did to look for particular syntax.

Learning from examples is a common strategy in CS and how you can learn new technology especially in a job, so today in class, we modeled that by looking for different syntax in the action files and building up what those things do.

## 13.4. Variables in Bash

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We can create variables like `VARNAME=value`.

Not  
Add  
here

```
NAME='Sarah'
```

notice that there are **no spaces** around the `=`. spaces in bash separate commands and options, so they cannot be in variable declarations.

A common mistake is to put a space around the `=` sign, this is actually considered **good style** in many other languages.

```
NAME ='Sarah'
```

```
-bash: NAME: command not found
```

In bash, however, this creates an error. When there is a space after `NAME`, `bash` tried to interpret `NAME` as a bash command, but then it does not find it, so it gives an error.

```
NAME='Sarah'
```

We can use variables with a `$` before the variable name.

```
echo $NAME
```

```
Sarah
```

### ! Important

This variable is local, in memory, to the current terminal window, so if we open a separate window and try `echo $NAME` it will not work. We can also see that it does not create any file changes.

```
echo $NAME
```

```
Sarah
```

We can see that it does not create any files by comparing ls now to what it was before:

```
ls
```

fa23-kwl-brownsarahm fall2023 ghic	github-inclass-fa23-brownsarahm test tiny-book
------------------------------------------	------------------------------------------------------

```
ls -a
```

[Skip to main content](#)

```
.
..
fa23-kwl-brownsarahm
fall2023
ghic
github-inclass-fa23-brownsarahm
test
tiny-book
```

We can, however use the variable at different working directories. So if we move

```
cd github-inclass-fa23-brownsarahm/
```

and `echo` again

```
echo $NAME
```

```
Sarah
```

it still works!

The `$` is essential syntax for recalling variables in bash. If we forget it, it treats it as a literal

```
echo NAME
```

```
NAME
```

so we get the variable **name** out instead of the variable **value**

We'll go back up a level now:

```
cd ..
```

## 13.5. Bash Loops

We can also make loops like

```
for loopvar in list
do
loop body
echo $loopvar
done
```

So for example we can loop over some names

```
for name in Sarah Amoy Marcin
> do
> echo $name
> done
```

A few important things, to make note of:

! Imp  
If you  
error,  
this c  
butyo

- lists in bash are defined with no brackets and no commas `Sarah Amoy Marcin` is a list
- we start the loop body with `do` and close it with `done` these are like the `{` and `}` in some languages.
- after we start the loop with a line starting with `for` bash continues that “command” by putting `>` at the start of each line until we end the loop with `done` and then it runs.

And we see it echos each name:

```
Sarah
Amoy
Marcin
```

Note that the loop variable is not scope limited to the loop. After the loop it still has the same value of the last time through the loop.

```
echo $name
```

```
Marcin
```

When we get the command back with the up arrow key, it puts it all on one line, because it was one command. The `;` (semicolon) separates the “lines”

We can add another name in

```
for name in Sarah Amoy Marcin Osman; do echo $name; done
```

```
Sarah
Amoy
Marcin
Osman
```

the output is like before, but with one more

```
echo $name
```

```
Osman
```

and this time `Osman` is the name left in the loop variable later.

## 13.6. Nesting commands

There are examples of this in your KWL repo actions. If we want the output of a command to be in a variable this is how to do it.

To do this, let's move to a folder with some files in it.

```
cd github-inclass-fa23-brownsarahm/
```

here we have a number of files in this working directory

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```
ls
```

```
API.md abstract_base_class.py important_classes.py
CONTRIBUTING.md alternative_classes.py setup.py
LICENSE.md docs tests
README.md helper_functions.py
```

We can run a command to generate the list by putting it inside `$( )` to run that command first. Think kind of like PEMDAS and the `$` in bash is for variables.

```
for FILE in $(ls)
> do
> echo $FILE
> done
```

```
API.md
CONTRIBUTING.md
LICENSE.md
README.md
abstract_base_class.py
alternative_classes.py
docs
helper_functions.py
important_classes.py
setup.py
tests
```

the `$( )` tells bash to run that command first and then hold its output as a variable for use elsewhere

For example, in your `getassignment.yml` I have a line like this:

```
pretitle="prepare-$(sysgetbadgedate --prepare)
```

it creates a variable that is “prepare-” concatenated with the output of `sysgetbadgedate --prepare`

```
echo $pretitle
```

```
prepare-2023-10-26
```

We can also modify our previous loop with an option:

```
for FILE in $(ls -a); do echo $FILE; done
```

```
.
..
.git
.github
API.md
CONTRIBUTING.md
LICENSE.md
README.md
abstract_base_class.py
```

[Skip to main content](#)

```
helper_functions.py
important_classes.py
setup.py
tests
```

## 13.7. Conditionals in bash

We can also do conditional statements

```
if test -f docs
> then
> echo "file"
> fi
```

the key parts of this:

- `test` checks if a file or directory exists
- the `-f` option makes it check if the item is a *file*
- what to do if the condition is met goes after a `then` keyword
- the `fi` (backwards `if`) closes the if statement
- the `>` work again like the loop and the `\`` we did in the past

this if does nothing though, because `docs` is a directory not a file.

If we switch it, we get output:

```
if test -f API.md ; then echo "file"; fi
```

```
file
```

## 13.8. Script files

We can put our script into a file

```
nano filecheck.sh
```

and check the content of the file

```
cat filecheck.sh
```

```
for file in $(ls)
do
 if test -f $file
 then
 echo $file
 fi
done
```

and run it with `bash <filename>`

```
bash filecheck.sh
```

```
API.md
CONTRIBUTING.md
LICENSE.md
README.md
abstract_base_class.py
alternative_classes.py
filecheck.sh
helper_functions.py
important_classes.py
setup.py
```

And this is as `ls` except without the folders:

```
ls
```

```
API.md abstract_base_class.py helper_functions.py
CONTRIBUTING.md alternative_classes.py important_classes.py
LICENSE.md docs setup.py
README.md filecheck.sh tests
```

### ! Important

We also looked at the structure and some examples of the action files in the KWL repo and course website.

I recommend the docs, starting from the [quickstart](#) and the [understand](#) section

## 13.9. Using GH

```
cd ../fall2023/
```

```
gh pr list
```

```
Showing 5 of 5 open pull requests in introcompsys/fall2023
```

```
#15 Create mermaid.md introcompsys:trevmoy-pat... about 5 days ago
#12 sample proposals for 212... 212build about 10 days ago
#11 Community-typos jacksonarich:main about 16 days ago
#10 Hash notes NoahV17:hash_notes about 18 days ago
#5 Added question to 9 26 n... NoahV17:added-question-t... about 23 days ago
```

Grep can search content, so with a pipe we can use it to filter results.

```
gh pr list | grep sample
```

[Skip to main content](#)

## 13.10. Terminal coloring and customizing your prompt.

Your path settings, aliases, and the your prompt can be set with a file.

On MacOS the file is called `.bash_profile` and is stored at your `~` home directory. If you use `zsh` instead of bash there is a different file, but it is similar.

On linux it is `.bashrc` it should be the same in WSL on Windows.

### 🔔 Community Badge opportunity

If you use windows, can you PR to update these notes with what file is used and which terminal/shell you are using (bash via GitBash, powershell, bash in WSL, etc. )

```
cat ~/.bash_profile
```

I have some aliases set, this way when I use Python, I can use the `python` command instead of `python3`.

the `PS1` variable describes the main default prompt, according to the spec. this tool can help you customize your prompt

```
alias pip=python3
alias python=python3

export PS1="\u@\W \$ "

>>> conda initialize >>
!! Contents within this block are managed by 'conda init' !!
__conda_setup=$(('/Users/brownsarahm/anaconda3/bin/conda' 'shell.bash' 'hook' 2> /dev/null)
if [$? -eq 0]; then
 eval "$__conda_setup"
else
 if [-f "/Users/brownsarahm/anaconda3/etc/profile.d/conda.sh"]; then
 . "/Users/brownsarahm/anaconda3/etc/profile.d/conda.sh"
 else
 export PATH="/Users/brownsarahm/anaconda3/bin:$PATH"
 fi
fi
unset __conda_setup
<<< conda initialize <<<
```

## 13.11. Prepare for Next Class

1. Read the 3 bulleted examples of [why use a cluster](#) from HPC carpentry.
2. Read [this discussion](#) of why using a remote server

## 13.12. Review Badge

1. Update your KWL Chart learned column with what you've learned
2. Write a bash script that you can run in your group repo to generate a file with a list of all of your PRs and. Save the script as `groupcontributions.sh` and its output as `group_contributions-YYYY-MM-DD.md` in your KWL repo.

## 13.13. Practice Badge

1. Update your KWL Chart learned column with what you've learned
2. Write a bash script that you can run in your group repo to generate a file with a list of all of your PRs and PR reviews (you may go in and assign yourself to these PRs to make this easier). Save the script as groupcontributions.sh and its output as group\_contributions-YYYY-MM-DD.md in your KWL repo.

## 13.14. Experience Report Evidence

### 13.15. Questions After Today's Class

#### 13.15.1. How often will we be writing scripts for this class?

Just a few times to get practice and exposure, but they will come back in 412 and are handy in general.

#### 13.15.2. Are bash scripts commonly used today in real world applications or is it something that was used more in the 70s?

They are still super common. GitHub actions can be written using bash scripting as a strategy. Lots of systems have build scripts.

The thing we would not do that often that we did today was write it from nano instead of a full IDE.

#### 13.15.3. What is the scope of loop variables?

In bash the loop variable has the same scope as any other variable. It is the same in Python. This is one of the many features that can vary from language to language.

#### 13.15.4. When would I use bash instead of a different programming language?

When you need to do things that are file operations or other os level actions, it can be faster to run if it is in bash.

#### 13.15.5. What specific tasks do developers like to use bash to automate?

build processes, file manipulations, git operations. Anything even just a few steps that would be repetitive and you would have to do often.

#### 13.15.6. do people write full programs in bash using things like nano or directly into the terminal?

Yes! Some people especially people who started programming a long time ago still do.

More often, using a terminal text editor is a handy tool to use on occasion, but not for every day work. We will work on a remote server, which is an occasion you would use that, on Thursday.

### 13.15.7. Is there a way to save files that you create in the shell?

yes, today we saved the `filecheck.sh` file.

### 13.15.8. what else can we do with bash?

Its mostly for automating things and processing files or outputs.

It *can* do anything though.

### 13.15.9. Does running a bash script with `bash` remove the need to add `#!/bin/bash` to the top of it and then make it executable prior to running?

Yes. by running it like `bash <filename>` it works just like passing those lines in the file to bash.

Alternatively you can put the shebang `#!/bin/bash` at the top to tell the computer what shell to use to run it and then treat it as an executable.

We will learn about making it executable permissions wise on Thursday.

### 13.15.10. Is it possible to create functions in bash scripts?

Yes! see the [GNU bash docs on functions](#)

### 13.15.11. Where would we see bash the most as a developer? Would we use this language more for an embedded swe role or is it something that's present in every type of programming job.

I think it's present in just about any programming job. You will always need to work with files at times, you will always have repetitive things that you do not want to do manually. You may write more or less, but it's always a handy tool to have.

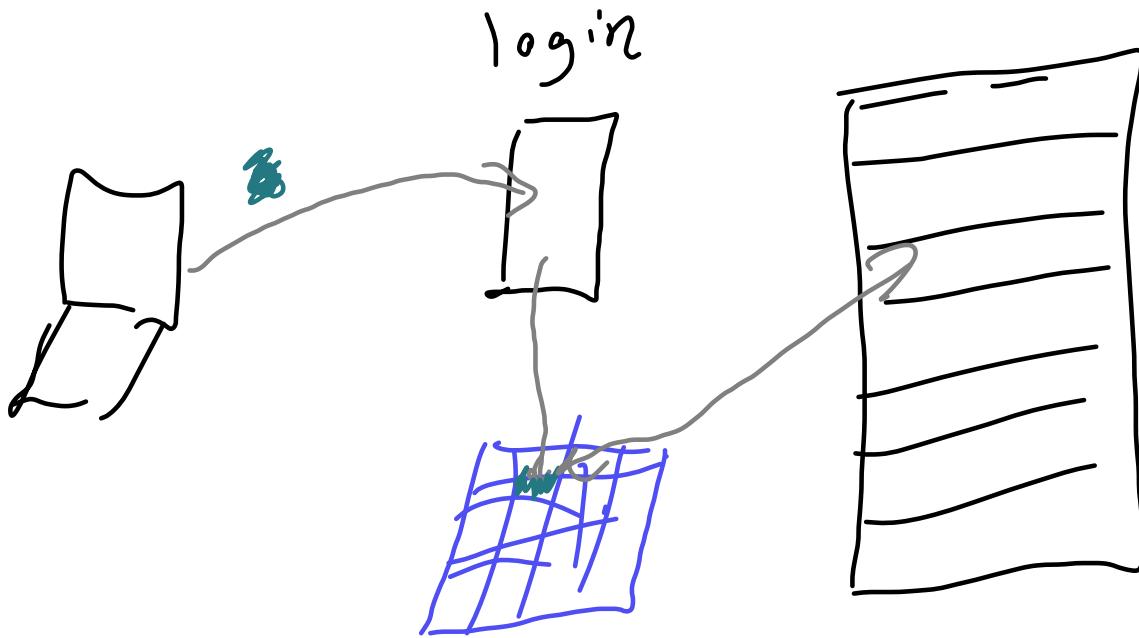
### 13.15.12. Where could I learn more about writing something similar to the workflows we saw?

The [github actions documentation](#) has instructions with how tos, API like documentation, and examples.

## 14. How can I work on a remote server?

Today we will connect to a remote server and learn new bash commands for working with the *content* of files.

### 14.1. What are remote servers and HPC systems?



## 14.2. Connecting to Seawulf

We connect with secure shell or `ssh` from our terminal (GitBash or Putty on windows) to URI's teaching High Performance Computing (HPC) Cluster Seawulf.

Our login is the part of your uri e-mail address before the @.

```
ssh -l brownsarahm seawulf.uri.edu
```

When it logs in it looks like this and requires you to change your password. They configure it with a default and with it past expired.

### Note

This block is sort of weird, because it is interactive terminal. I have rendered it all as output, but broken it down to separate chunks to add explanation.

let me know your thoughts on this choice for a community badge

```
The authenticity of host 'seawulf.uri.edu (131.128.217.210)' can't be established.
ECDSA key fingerprint is SHA256:RwhTUyjWLqwohXiRw+tY1TiJEbqX2n/drCpkIwQVCro.
Are you sure you want to continue connecting (yes/no/[fingerprint])? y
Please type 'yes', 'no' or the fingerprint: yes
```

Follow the instruction to type `yes`

I will tell you how to find your default password if you missed class (do not want to post it publicly). Comment on your experience report PR to ask for this information.

### Warn

This c  
purpo  
HPC  
projec  
Servic  
Azul S  
allocat

If you  
by a t  
serve  
partic  
resou

It does not show characters when you type your password, but it works when you press enter

Then it requires you to change your password

```
You are required to change your password immediately (root enforced)
WARNING: Your password has expired.
You must change your password now and login again!
```

To change, it asks for your current (default) password first,

#### ! Important

You use the default password when prompted for your username's password. Then again when it asks for the **(current) UNIX password:**. Then you must type the same, new password twice.

**Choose a new password you will remember, we will come back to this server**

```
Changing password for user brownsarahm.
Changing password for brownsarahm.
(current) UNIX password:
```

then the new one twice

```
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
Connection to seawulf.uri.edu closed.
```

after you give it a new password, then it logs you out and you have to log back in.

```
brownsarahm@~ $ ssh -l brownsarahm seawulf.uri.edu
```

When you log in it shows you information about your recent logins.

We have logged into our home directory which is empty

```
[brownsarahm@seawulf ~]$ ls
```

```
[brownsarahm@seawulf ~]$ pwd
```

```
/home/brownsarahm
```

Notice that the prompt says **uriusername@seawulf** to indicate that you are logged into the server, not working locally.

## 14.3. Downloading files

[Skip to main content](#)

```
[brownsarahm@seawulf ~]$ wget http://www.hpc-carpentry.org/hpc-shell/files/bash-lesson.tar.gz
```

```
--2022-03-08 12:58:09-- http://www.hpc-carpentry.org/hpc-shell/files/bash-lesson.tar.gz
Resolving www.hpc-carpentry.org (www.hpc-carpentry.org)... 104.21.33.152, 172.67.146.136
Connecting to www.hpc-carpentry.org (www.hpc-carpentry.org)|104.21.33.152|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 12534006 (12M) [application/gzip]
Saving to: 'bash-lesson.tar.gz'

100%[=====] 12,534,006 4.19MB/s in 2.9s

2022-03-08 12:58:12 (4.19 MB/s) - 'bash-lesson.tar.gz' saved [12534006/12534006]
```

Note that this is a reasonably sized download and it finished very quickly. This is because the download happened **on the remote server** not your laptop. The server has a high quality hard-wired connection to the internet that is very fast, unlike the wifi in our classroom.

This is an advantage of using a remote system. If your connection is slow, but stable enough to connect, you can do the work on a different computer that has better connection.

Now we see we have the file.

```
[brownsarahm@seawulf ~]$ ls
```

```
bash-lesson.tar.gz
```

we see the new file!

## 14.4. Unzipping a file on the command line

This file is compressed.

We can use `man tar` to see the manual aka man file of the `tar` program to learn how it works. You can also read man files online from [GNU](#) where you can choose your format, [this page shows the full version](#).

```
[brownsarahm@seawulf ~]$ tar -xvf bash-lesson.tar.gz
```

```
dmel-all-r6.19.gtf
dmel_unique_protein_isoforms_fb_2016_01.tsv
gene_association.fb
SRR307023_1.fastq
SRR307023_2.fastq
SRR307024_1.fastq
SRR307024_2.fastq
SRR307025_1.fastq
SRR307025_2.fastq
SRR307026_1.fastq
SRR307026_2.fastq
SRR307027_1.fastq
SRR307027_2.fastq
SRR307028_1.fastq
SRR307028_2.fastq
SRR307029_1.fasta
```

[Skip to main content](#)

```
SRR307030_1.fastq
SRR307030_2.fastq
```

This command uses the `tar` program and:

- makes it verbose (to output all that info while it works)
- makes it extract
- option accepts the file name to work on

We can see what it did with `ls`

```
[brownsarahm@seawulf ~]$ ls
```

bash-lesson.tar.gz	SRR307026_1.fastq
dmel-all-r6.19.gtf	SRR307026_2.fastq
dmel_unique_protein_isoforms_fb_2016_01.tsv	SRR307027_1.fastq
gene_association.fb	SRR307027_2.fastq
SRR307023_1.fastq	SRR307028_1.fastq
SRR307023_2.fastq	SRR307028_2.fastq
SRR307024_1.fastq	SRR307029_1.fastq
SRR307024_2.fastq	SRR307029_2.fastq
SRR307025_1.fastq	SRR307030_1.fastq
SRR307025_2.fastq	SRR307030_2.fastq

**Note:** To extract files to a different directory use the option `--directory` `--directory path/to/directory`

## 14.5. Using a compute note

## 14.6. Working with large files

One of these files, contains the entire genome for the common fruitfly, let's take a look at it:

```
[brownsarahm@seawulf ~]$ cat dmel-all-r6.19.gtf
```

```
X FlyBase gene 19961297 19969323 . + . gene_id "FBgn0031081"; gene_s
2L FlyBase 3UTR 782825 782885 . + . gene_id "FBgn0041250"; gene_symbol "Gr21a";
```

### ⚠ Warning

this output is truncated for display purposes

We see that this actually takes a long time to output and is way too much information to actually read. In fact, in order to make the website work, I had to cut that content using command line tools, my text editor couldn't open the file and GitHub was unhappy when I pushed it.

## **i** Note

I initially used `head` and `tail` to pick out the excerpts of the terminal output that I needed, but this year I reused what I had done before

For a file like this, we don't really want to read the whole file but we do need to know what it's structured like in order to design programs to work with it.

`head` lets us look at the first 10 lines.

```
[brownsarahm@seawulf ~]$ head dmel-all-r6.19.gtf
```

X	FlyBase gene	19961297	19969323	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase mRNA	19961689	19968479	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase 5UTR	19961689	19961845	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19961689	19961845	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19963955	19964071	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19964782	19964944	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19965006	19965126	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19965197	19965511	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19965577	19966071	.	+	.	gene_id "FBgn0031081"; gene_
X	FlyBase exon	19966183	19967012	.	+	.	gene_id "FBgn0031081"; gene_

We use the `man` file for `head` to look at its options.

Historically there were only the single character options, but these are limited (you can only have 52) and cryptic. They were good though when you only could type and had minimal memory. the longer ones are good because they are more descriptive.

The long versions are better to use in scripts because they are easier for someone else to read. The single character versions save time when you are working interactively.

We can use the `-n` parameter to change the number.

And, tails shows the last few.

```
[brownsarahm@seawulf ~]$ tail dmel-all-r6.19.gtf
```

which in this case looks mostly the same

2L	FlyBase exon	782124	782181	.	+	.	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase exon	782238	782441	.	+	.	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase exon	782495	782885	.	+	.	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase start_codon	781297	781299	.	+	0	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase CDS	781297	782048	.	+	0	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase CDS	782124	782181	.	+	1	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase CDS	782238	782441	.	+	0	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase CDS	782495	782821	.	+	0	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase stop_codon	782822	782824	.	+	0	gene_id "FBgn0041250"; gene_symbol "Gr21a";
2L	FlyBase 3UTR	782825	782885	.	+	.	gene_id "FBgn0041250"; gene_symbol "Gr21a";

We can also see how much content is in the file `wc` give a word count and with its `-l` parameter gives us the number of lines.

```
[brownsarahm@seawulf ~]$ wc -l dmel-all-r6.19.gtf
```

[Skip to main content](#)

```
542048 dmel-all-r6.19.gtf
```

Over five hundred forty thousand lines is a lot.

How can we get the number of lines in each of the `.fastq` files?

```
[brownsarahm@seawulf ~]$ wc -l *.fastw
wc: *.fastw: No such file or directory
```

note that in my typo, it tells me no files matched my pattern.

```
[brownsarahm@seawulf ~]$ wc -l *.fastq
20000 SRR307023_1.fastq
20000 SRR307023_2.fastq
20000 SRR307024_1.fastq
20000 SRR307024_2.fastq
20000 SRR307025_1.fastq
20000 SRR307025_2.fastq
20000 SRR307026_1.fastq
20000 SRR307026_2.fastq
20000 SRR307027_1.fastq
20000 SRR307027_2.fastq
20000 SRR307028_1.fastq
20000 SRR307028_2.fastq
20000 SRR307029_1.fastq
20000 SRR307029_2.fastq
20000 SRR307030_1.fastq
20000 SRR307030_2.fastq
320000 total
```

when it does work, we also get the total.

We can use redirects as before to save these to a file:

```
[brownsarahm@seawulf ~]$ wc -l *.fastq > linecounts.txt
```

```
[brownsarahm@seawulf ~]$ cat linecounts.txt
20000 SRR307023_1.fastq
20000 SRR307023_2.fastq
20000 SRR307024_1.fastq
20000 SRR307024_2.fastq
20000 SRR307025_1.fastq
20000 SRR307025_2.fastq
20000 SRR307026_1.fastq
20000 SRR307026_2.fastq
20000 SRR307027_1.fastq
20000 SRR307027_2.fastq
20000 SRR307028_1.fastq
20000 SRR307028_2.fastq
20000 SRR307029_1.fastq
20000 SRR307029_2.fastq
20000 SRR307030_1.fastq
20000 SRR307030_2.fastq
320000 total
```

We can also search files, without loading them all into memory or displaying them, with `grep`:

```
brownsarahm@seawulf ~]$ grep Act5c dmel-all-r6.19.gtf
```

[Skip to main content](#)

```
[brownsarahm@seawulf ~]$ grep mRNA dmel-all-r6.19.gtf
```

this output a lot, so the output is truncated here

```
X FlyBase mRNA 19961689 19968479 . + . gene_id "FBgn0031081"; gene_
2L FlyBase mRNA 781276 782885 . + . gene_id "FBgn0041250"; gene_symbol "Gr21a";
```

and we can combine `grep` with `wc` to count occurrences.

```
[brownsarahm@seawulf ~]$ grep mRNA dmel-all-r6.19.gtf | wc -l
34025
```

## 14.7. Feedback

### Note

will fill in later

## 14.8. Prepare for Next Class

1. Read about [connection protocols](#) in general and specifically https and ssh. Wikipedia is a good source to start from, and use additional sources to verify anything you find confusing. Be sure you have the basic terminology down and bring questions to class. Plan to check off your questions as they are answered during class on Tuesady and then submit others in your experience reflection.

## 14.9. Review today's class

### Important

This is an integrative 2x badge.

**integrative 2:** The PR title must be [review-2023-10-26](#) verbatim to get the double credit

create a [vocab-quiz.md](#) file with 10 mutliple choice questions that cover topics from at least 5 different class sessions. Each question should have 4 options, 1 correct and 3 that represent a reasonable, but incorrect idea someone may have. Questions should check that a person understand the key terms of the first half of the course. For each option explain why it is/not correct in a way that would help clarify someone's confusion if they had picked that answer instead of the correct answer.

\*\*For this badge you must request a review from [@brownsarahm](#) \*\*

Use the following syntax:

Question text

- [ ] a wrong answer

[Skip to main content](#)

```
- [] another wong

[section title](link/to/notes)
- explanation for first wrong
- explanation for second wrong
- key point about correct
- explantion for third wrong

```

Next question

## 14.10. Practice

### ! Important

This is an integrative 2x badge.

**integrative 2:** The PR title must be `practice-2023-10-26` verbatim to get the double credit

create a `midterm.md` file in your kwl repo with 10 mutliple choice questions that cover topics from at least 5 different class sessions. Each question should have 4 options, 1 correct and 3 that represent a reasonable, but incorrect idea someone may have. All 10 questions should check understanding of key *concepts*, not only terminology or the name of a command. For each option explain why it/is/not correct in a way that would help clarify someone's confusion if they had picked that answer instead of the correct answer. Each solution block must contain a link to the applicable class notes. \*\*For this badge you must request a review from `@brownsarahm` \*\*

Use the following syntax:

```
Question text
- [] a wrong answer
- [] another wrong
- [x] correct answer marked with x
- [] another wong

```

```
[section title](link/to/notes)
- explanation for first wrong
- explanation for second wrong
- key point about correct
- explantion for third wrong

```

Next question

## 14.11. Experience Report Evidence

No specific files.

## 14.12. Questions After Today's Class

### 14.12.1. Will we be incorporating remote server use with coding at all in this class? Maybe some bash scripts?

Yes. Some in lab tomorrow and more after we learn building C code.

### 14.12.2. When would we want to use as many resources as possible but the remote server would not be appropriate because we still need to connect to it?

This is an interesting question, but I can not come up with such a scenario.

### 14.12.3. What is a real use case of using a remote machine to do computing?

My research students, as do Professor Daniels' use a server to run their code because the problems are too big to do on a laptop.

ML works that way in industry too. As does real genomics research both in universities and in pharma companies.

### 14.12.4. How do I set up SSH keys for secure access to a remote Git server in Git Bash?(If possible)

We will set up ssh keys for server access in class next week and you will then be assigned to add them to git from GitHub docs.

### 14.12.5. Is it expensive to have a remote server?

At face value, yes, but they're typically shared costs. It might cost \$10-50k to add a unit to the server, but then each use is not.

You could look up billing for AWS, MSFT Azure, or Google Cloud to see hourly use rates on their servers.

Also, the cost is compared to people's salary being spent waiting around. Even  
*50k, that lasts for only 3 years, could be worth it, if you consider its savings time of people who each have a salary over over 100k/ year.*

### 14.12.6. how do we set up our own remote server?

This is a good explore badge topic, but not something I have personally ever done. If you actually build it out, it could be a build badge.

### 14.12.7. What are other large remote servers that are free to use, and are there unsafe servers?

Most are not really free. Some give free access to students, many give free trials.

Unsafe would be like insecure in this sense that the data is not secure.

#### **14.12.8. Would it be worthwhile to look into using a remote server for synchronizing school work between my laptop and my desktop (work beyond the scope of git/GitHub)?**

That's not the point of an HPC or server like we used today. That is a good use for GitHub, or a cloud service that is file-focused like DropBox.

#### **14.12.9. What's the point of Seawulf?**

To learn about using remote servers. It's separate from the research servers so that we doing low priority class work do not slow down people doing research. The research ones are also funded with grant dollars and Seawulf is not.

#### **14.12.10. What would be an instance that we may need to use a remote system for in school?**

in CSC411 there is a homework server so that all students have the same environment.

#### **14.12.11. How exactly computer intensive is graphics and pretty shapes, such that it is a necessity to cut them out for maximum computer resources available?**

This is a good explore badge topic to monitor over a bit of time how much of your compute resources are being used by visualization vs the actual computation.

You could do a small experiment where you print vs do not and time how long the code takes. This could be done in any language.

### **14.13. Questions after this topic in previous semesters**

#### **14.13.1. What is meant by the term “gene symbol” ?**

For the purpose of this class it is just a bit of the content in the file. For completeness, since the file is genomic data is a name for the gene at that line.

#### **14.13.2. When would I use these remote servers most often?**

Remote servers are used for production code, and for large computations in any sort of science setting or machine learning setting.

#### **14.13.3. What type of data structure for storage does the server we used today follow? How does it version track and store files?**

It is a regular unix system with a standard file system. If we want to track versions, we use git. (or another version control system)

#### **14.13.4. Will the files on our seawulf, still be available after exiting.**

Yes, but not forever. Seawulf is a teaching server that makes no promise of backing up or keeping your data forever.

### **14.13.5. What are .fastq and .gz files?**

.gz is a zip file, .fastq is a plain text output of a sequencing tool.

### **14.13.6. Can we connect to other servers other than the URI server?**

Yes, if you have credentials, the ssh works basically the same way. We will learn one more thing that will give you more ability to use other servers next week.

### **14.13.7. What is the point of a remote server?**

More compute power.

### **14.13.8. Do the files download directly to my computer or to the remote server?**

The file goes to the system where the command is run, in this case, it went to the the server.

### **14.13.9. where is the ssh server downloaded on my computer?**

ssh is the *connection protocol* or the set of rules by which our information is sent.

The server is another computer, you were using that computer *through* your local terminal.

We did not create any files on your local system today.

### **14.13.10. Is access to the chmod command restricted on computers and servers?**

on a file by file basis typically, eys.

### **14.13.11. Can I access the remote files using vscode and write code?**

Theoretically yes, but a more typical workflow would be to edit large files locally running vscode on your system then send the code to the remote server to run it. You might send one file at a time directly there or push from your local system to for example GitHub and then from GitHub on the server.

### **14.13.12. Will I work with files more like this or locally as a software engineer?**

Maybe not this type specifically, but you will almost surely encounter a large file at some point. You will also likely encounter a server for some reason.

### **14.13.13. for files that are impossible to open with text editors because they're too long, is it possible to edit parts of the file just through terminal commands?**

Yes! This is a good explore badge as well.

## 14.13.14. How can I zip from the terminal?

```
zip file file
```

## 14.13.15. Are you able to run a website through a terminal?

You could launch a web server from a terminal. You can also launch a browser.

For the course website when I build the pdf, version a bash script launches a browser, uses the browser's print to pdf function and closes the browser.

# 15. How can I run a job on a remote server ?

## 15.1. Logging back in to seawulf

First, we will log in as we did before :

```
ssh -l brownsarahm seawulf.uri.edu
```

```
brownsarahm@seawulf.uri.edu's password:
Last login: Thu Oct 26 13:03:10 2023 from 172.20.131.240
```

## 15.2. Creating a script

On a server where we only have terminal access, using a terminal text based editor is what we have. For larger code, we could use git or copy the files, but to edit on the server, we only have a terminal text editor:

```
nano example-job.sh
```

We will put the following in the file:

```
echo -n "this script is running on "
hostname
```

I used a new option on `echo` that we have not seen before and we used the documentation to work from there.

```
man echo
```

```
bash example-job.sh
```

```
this script is running on seawulf.uri.edu
```

```
./example-job.sh
```

```
-bash: ./example-job.sh: Permission denied
```

```
ls -l
```

```
total 138456
-rw-r--r--. 1 brownsarahm spring2022-csc392 12534006 Apr 18 2021 bash-lesson.tar.gz
drwxr-xr-x. 2 brownsarahm spring2022-csc392 4096 Apr 4 2023 compilec
-rw-r--r--. 1 brownsarahm spring2022-csc392 77426528 Jan 16 2018 dmel-all-r6.19.gtf
-rw-r--r--. 1 brownsarahm spring2022-csc392 721242 Jan 25 2016 dmel_unique_protein_isoforms_fb_2016_01.tsv
drwxr-xr-x. 3 brownsarahm spring2022-csc392 24 Mar 30 2023 example
-rw-r--r--. 1 brownsarahm spring2022-csc392 46 Oct 31 13:04 example-job.sh
-rw-r--r--. 1 brownsarahm spring2022-csc392 25056938 Jan 25 2016 gene_association.fb
-rw-r--r--. 1 brownsarahm spring2022-csc392 447 Oct 26 13:30 linecounts.txt
drwxr-xr-x. 2 brownsarahm spring2022-csc392 10 Mar 8 2022 results
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625262 Jan 25 2016 SRR307023_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625262 Jan 25 2016 SRR307023_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625376 Jan 25 2016 SRR307024_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625376 Jan 25 2016 SRR307024_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625286 Jan 25 2016 SRR307025_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625286 Jan 25 2016 SRR307025_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625302 Jan 25 2016 SRR307026_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625302 Jan 25 2016 SRR307026_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625312 Jan 25 2016 SRR307027_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625312 Jan 25 2016 SRR307027_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625338 Jan 25 2016 SRR307028_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625338 Jan 25 2016 SRR307028_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625390 Jan 25 2016 SRR307029_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625390 Jan 25 2016 SRR307029_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625318 Jan 25 2016 SRR307030_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625318 Jan 25 2016 SRR307030_2.fastq
```

```
chmod +x example-job.sh
```

```
ls -l | grep example
```

```
drwxr-xr-x. 3 brownsarahm spring2022-csc392 24 Mar 30 2023 example
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:04 example-job.sh
```

```
./example-job.sh
```

```
this script is running on seawulf.uri.edu
```

```
cp example-job.sh ex2.sh
cp example-job.sh ex3.sh
cp example-job.sh ex4.sh
```

```
ls | grep ex
```

```
ex3.sh
ex4.sh
example
example-job.sh
```

```
ls -l
```

```
total 138468
-rw-r--r--. 1 brownsarahm spring2022-csc392 12534006 Apr 18 2021 bash-lesson.tar.gz
drwxr-xr-x. 2 brownsarahm spring2022-csc392 4096 Apr 4 2023 compilec
-rw-r--r--. 1 brownsarahm spring2022-csc392 77426528 Jan 16 2018 dmel-all-r6.19.gtf
-rw-r--r--. 1 brownsarahm spring2022-csc392 721242 Jan 25 2016 dmel_unique_protein_isoforms_fb_2016_01.tsv
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex2.sh
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex3.sh
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex4.sh
drwxr-xr-x. 3 brownsarahm spring2022-csc392 24 Mar 30 2023 example
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:04 example-job.sh
-rw-r--r--. 1 brownsarahm spring2022-csc392 25056938 Jan 25 2016 gene_association.fb
-rw-r--r--. 1 brownsarahm spring2022-csc392 447 Oct 26 13:30 linecounts.txt
drwxr-xr-x. 2 brownsarahm spring2022-csc392 10 Mar 8 2022 results
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625262 Jan 25 2016 SRR307023_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625262 Jan 25 2016 SRR307023_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625376 Jan 25 2016 SRR307024_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625376 Jan 25 2016 SRR307024_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625286 Jan 25 2016 SRR307025_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625286 Jan 25 2016 SRR307025_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625302 Jan 25 2016 SRR307026_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625302 Jan 25 2016 SRR307026_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625312 Jan 25 2016 SRR307027_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625312 Jan 25 2016 SRR307027_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625338 Jan 25 2016 SRR307028_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625338 Jan 25 2016 SRR307028_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625390 Jan 25 2016 SRR307029_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625390 Jan 25 2016 SRR307029_2.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625318 Jan 25 2016 SRR307030_1.fastq
-rw-r--r--. 1 brownsarahm spring2022-csc392 1625318 Jan 25 2016 SRR307030_2.fastq
```

```
chmod -x ex*.sh
```

```
ls -l | grep ex
```

```
-rw-r--r--. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex2.sh
-rw-r--r--. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex3.sh
-rw-r--r--. 1 brownsarahm spring2022-csc392 46 Oct 31 13:20 ex4.sh
drwxr-xr-x. 3 brownsarahm spring2022-csc392 24 Mar 30 2023 example
-rwxr-xr-x. 1 brownsarahm spring2022-csc392 46 Oct 31 13:04 example-job.sh
```

```
./example-job.sh
```

```
-bash: ./example-job.sh: Permission denied
```

```
chmod +x example-job.sh
```

```
./example-job.sh
```

[Skip to main content](#)

```
this script is running on seawulf.uri.edu
```

```
nano example-job.sh
```

```
cat example-job.sh
```

```
#!/bin/bash
#SBATCH -J hello-world

echo -n "this script is running on "
hostname
```

```
sbatch example-job.sh
```

```
Submitted batch job 27093
```

```
squeue -u brownsarahm
```

JOBID	PARTITION	NAME	USER	ST	TIME	NODES	NODELIST(Reason)
-------	-----------	------	------	----	------	-------	------------------

```
sbatch example-job.sh
```

```
Submitted batch job 27107
```

```
squeue -u brownsarahm
```

JOBID	PARTITION	NAME	USER	ST	TIME	NODES	NODELIST(Reason)
-------	-----------	------	------	----	------	-------	------------------

```
whoami
```

```
brownsarahm
```

```
ls
```

bash-lesson.tar.gz	linecounts.txt	SRR307026_1.fastq
compilec	results	SRR307026_2.fastq
dmel-all-r6.19.gtf	slurm-27093.out	SRR307027_1.fastq
dmel_unique_protein_isoforms_fb_2016_01.tsv	slurm-27107.out	SRR307027_2.fastq
ex2.sh	SRR307023_1.fastq	SRR307028_1.fastq
ex3.sh	SRR307023_2.fastq	SRR307028_2.fastq
ex4.sh	SRR307024_1.fastq	SRR307029_1.fastq
example	SRR307024_2.fastq	SRR307029_2.fastq

[Skip to main content](#)

```
cat slurm-27093.out
```

```
this script is running on n005.cluster.com
```

```
cat slurm-27107.out
```

```
this script is running on n005.cluster.com
```

```
nano example-job.sh
```

```
logout
Connection to seawulf.uri.edu closed.
```

```
ssh -l brownsarahm seawulf.uri.edu
```

```
brownsarahm@seawulf.uri.edu's password:
Permission denied, please try again.
brownsarahm@seawulf.uri.edu's password:
Last failed login: Tue Oct 31 13:41:13 EDT 2023 from 172.20.131.240 on ssh:notty
There were 3 failed login attempts since the last successful login.
Last login: Tue Oct 31 12:59:02 2023 from 172.20.131.240
```

```
cat ex2.sh
echo -n "this script is running on "
hostname
```

```
chmod +x ex2.sh
```

```
sbatch -J hello -o name-%j ex2.sh
```

```
sbatch: error: This does not look like a batch script. The first
sbatch: error: line must start with #! followed by the path to an interpreter.
sbatch: error: For instance: #!/bin/sh
```

```
nano ex2.sh
```

```
sbatch -J hello -o name-%j ex2.sh
Submitted batch job 27140
```

```
ls |grap name
-bash: grap: command not found
```

```
ls |grep name
name-27140
```

```
sbatch ex2.sh
Submitted batch job 27141
```

```
sysapprovedbages
```

```
-bash: sysapprovedbages: command not found
```

```
sysapprovedbadges --help
```

```
-bash: sysapprovedbadges: command not found
```

```
exit
```

```
Connection to seawulf.uri.edu closed.
```

## 15.3. Prepare for Next Class

No separate preparation, focus on badge work and reviewing the notes if you missed class.

Make sure you did the prep for 10-31, we will work from that on 11/2.

## 15.4. Review today's class

- File permissions are represented numerically often in octal, by transforming the permissions for each level (owner, group, all) as binary into a number. Add octal.md to your KWL repo and answer the following. Try to think through it on your own, but you may look up the answers, as long as you link to (or ideally cite using jupyterbook citations) a high quality source.

```
1. Describe how to transform the permissions ['r--', 'rw-', 'rwx'] to octal, by treating each set as three
1. Transform the permission we changed our script to 'rwxr-xr-x' to octal.
1. Which of the following would prevent a file from being edited by other people 777 or 755 and why?
```

## 15.5. More Practice

- File permissions are represented numerically often in octal, by transforming the permissions for each level (owner, group, all) as binary into a number. Add octal.md to your KWL repo and answer the following. Try to think through it on your own, but you may look up the answers, as long as you link to (or ideally cite using jupyterbook citations) a high quality source.

```
1. Describe how to transform the permissions ['r--', 'rw-', 'rwx'] to octal, by treating each set as three
```

[Skip to main content](#)

2. Answer the following in hpc.md of your KWL repo: (to think about how the design of the system we used in class impacts programming and connect it to other ideas taught in CS)

1. What kinds of things would your code need to do if you were going to run it on an HPC system?
1. What sbatch options seem the most helpful?
1. How might you go about setting the time limits for a script? How could you estimate how long a script

## 15.6. Experience Report Evidence

none

## 15.7. Questions After Today's Class

### 15.7.1. Will we be writing more intricate bash scripts down the line?

only slightly in this class. In CSC412, you will learn more elaborate scripting, this course is to get you the basics.

### 15.7.2. why are files not executable by default?

For safety, an executable could manipulate other files, you do not want to do that by accident.

### 15.7.3. When looking at the access permission, -rwxrwxrwx, how do you change just one of the levels and not all of them at once? like if i want to change perms for just the lowest level.

This can be answered using the `man` file for `chmod`

### 15.7.4. When can I use this in practice?

Whenever you want to execute a file, modifying the permissions is necessary

### 15.7.5. How can you change the permissions of a file using the chmod command in Bash?

with `chmod`

### 15.7.6. Can bash scripts call other bash scripts?

Yes!

### 15.7.7. Would having a file without the read permissions essentially make the file

Yes

### 15.7.8. Is seawulf something we just have access to during this semester or will we have access to it after?

technically, your access may not be revoked, but this server is designed only for teaching. That means that is relatively low-powered and has very minimal data storage.

If you are doing a side project, I recommend using a commerical server system like google cloud or aws.

If you are doing research with a professor, ask them for access to a server that URI has for research.

### 15.7.9. Do other servers have the ability to create scripts with languages besides Bash?

Some may have other default shells, but even on a server that uses bash you can run other code. We will do that soon, we will write some C code and then run it from a bash script.

### 15.7.10. How else can we work in seawulf to improve our skills with CLI tools?

The badges for thursday and this week's lab will continue to build on these skills.

## 16. SSH Keys and Building Code

### ⚠ Warning

This is not filled in yet. Use a previous semester until then

f22 build

```
ssh -l brownsarahm seawulf.uri.edu
```

```
brownsarahm@seawulf.uri.edu's password:
Last login: Tue Oct 31 13:41:16 2023 from 172.20.131.240
```

```
[brownsarahm@seawulf ~]$ logout
Connection to seawulf.uri.edu closed.
```

```
ssh-keygen -f ~/seawulf -t rsa -b 1024
```

```
Generating public/private rsa key pair.
/Users/brownsarahm/seawulf already exists.
Overwrite (y/n)? y
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
```

[Skip to main content](#)

```
The key fingerprint is:
SHA256:/jDn06CDu24k1K2z4dw6achJuzax9685qHLaGeooX9g brownsarahm@240.131.20.172.s.wireless.uri.edu
The key's randomart image is:
+--[RSA 1024]--
|
|
| o
| o .
| + o S
| o@ .. .
| .oE& o+..o
| ...+&o* +B. .
| oo=**X+++++=.
```

it asks you for an optional password to lock the key itself.

```
ssh-copy-id -i ~/seawulf brownsarahm@seawulf.uri.edu
```

```
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/Users/brownsarahm/seawulf.pub"
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already ins
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the i
brownsarahm@seawulf.uri.edu's password:
```

```
Number of key(s) added: 1
```

```
Now try logging into the machine, with: "ssh 'brownsarahm@seawulf.uri.edu'"
and check to make sure that only the key(s) you wanted were added.
```

```
cd
```

```
ls -a
```

```
. viminfo
.. virtual_documents
.CFUserTextEncoding vscode
.DS_Store xonshrc
.Rhistory zsh_history
.Trash zsh_sessions
.anaconda zshrc
.anaconda_backup 2023-01-24.md
.atom Applications
.bash_history Creative Cloud Files
.bash_profile Desktop
.bash_profile.pysave DigiCertHighAssuranceEVRootCA.crt
.bash_sessions Documents
.bundle Downloads
.cache Dropbox
.conda Library
.condarc Movies
.config Music
.continuum Pictures
.cups Public
.dropbox PycharmProjects
.gem Untitled.ipynb
.gitconfig Untitled1.ipynb
.ipynb_checkpoints Untitled2.ipynb
.ipython Untitled3.ipynb
```

[Skip to main content](#)

```
.local anaconda3
.matplotlib bash_profile.backup2023-09-06
.mono ca-bundle.crt
.npm configs
.python_history demo.ipynb
.r scikit_learn_data
.rbsenv seaborn-data
.ssh seawulf
.tcshrc seawulf.pub
```

```
ls .ssh
```

```
config known_hosts seawulf seawulf.pub
```

```
cd Documents/inclass/systems/
```

```
ssh -i ~/.ssh/seawulf brownsarah@seawulf.uri.edu
```

```
brownsarah@seawulf.uri.edu's password:
```

```
ssh -i ~/seawulf brownsarah@seawulf.uri.edu
```

```
brownsarah@seawulf.uri.edu's password:
Permission denied, please try again.
brownsarah@seawulf.uri.edu's password:
Permission denied, please try again.
brownsarah@seawulf.uri.edu's password:
brownsarah@seawulf.uri.edu: Permission denied (publickey,gssapi-keyex,gssapi-with-mic,password).
```

```
ls ~ |grep seawulf
```

```
ls ~ |grep seawulf
```

```
seawulf
seawulf.pub
```

```
ssh -i ~/seawulf brownsarahm@seawulf.uri.edu
```

```
Last login: Thu Nov 2 12:36:20 2023 from 172.20.131.240
[brownsarahm@seawulf ~]$ interactive
[0000] Granted job allocation 27157
```

[Skip to main content](#)

```

salloc: Nodes n005 are ready for job
[brownsarahm@n005 ~]$ hostname
n005.cluster.com
[brownsarahm@n005 ~]$ mkdir compilec
mkdir: cannot create directory 'compilec': File exists
[brownsarahm@n005 ~]$ rm -rf compilec/
[brownsarahm@n005 ~]$ mkdir compilec
[brownsarahm@n005 ~]$ cd compilec/
[brownsarahm@n005 compilec]$ ls
[brownsarahm@n005 compilec]$ nano hello.c
[brownsarahm@n005 compilec]$ cat hello.c
#include <stdio.h>
void main () {
 printf("Hello world\n");
}
[brownsarahm@n005 compilec]$ ls
hello.c
[brownsarahm@n005 compilec]$ gcc -E hello.c -o hello.i
[brownsarahm@n005 compilec]$ ls
hello.c hello.i
[brownsarahm@n005 compilec]$ cat hello.i |head
1 "hello.c"
1 "<built-in>"
1 "<command-line>"
1 "/usr/include/stdc-predef.h" 1 3 4
1 "<command-line>" 2
1 "hello.c"
1 "/usr/include/stdio.h" 1 3 4
27 "/usr/include/stdio.h" 3 4
1 "/usr/include/features.h" 1 3 4
375 "/usr/include/features.h" 3 4
[brownsarahm@n005 compilec]$ cat hello.i |tail

extern void funlockfile (FILE * __stream) __attribute__ ((__nothrow__ , __leaf__));
943 "/usr/include/stdio.h" 3 4

2 "hello.c" 2
void main () {
 printf("Hello world\n");
}
[brownsarahm@n005 compilec]$ cat hello.i | wc-1
bash: wc-1: command not found
[brownsarahm@n005 compilec]$ cat hello.i | wc -l
842
[brownsarahm@n005 compilec]$ cat hello.c | wc -l
6
[brownsarahm@n005 compilec]$ gcc -S hello.i
[brownsarahm@n005 compilec]$ ls
hello.c hello.i hello.s
[brownsarahm@n005 compilec]$ cat hello.s
 .file "hello.c"
 .section .rodata
.LC0:
 .string "Hello world"
 .text
 .globl main
 .type main, @function
main:
.LFB0:
 .cfi_startproc
 pushq %rbp
 .cfi_def_cfa_offset 16
 .cfi_offset 6, -16
 movq %rsp, %rbp
 .cfi_def_cfa_register 6
 movl $.LC0, %edi
 call puts
 .none %rhn

```

```

.cfi_endproc
.LFE0:
.size main, .-main
.ident "GCC: (GNU) 4.8.5 20150623 (Red Hat 4.8.5-44)"
.section .note.GNU-stack,"",@progbits
[brownsarahm@n005 compilec]$ gcc -c hello.s -o hello.o
[brownsarahm@n005 compilec]$ ls
hello.c hello.i hello.o hello.s
[brownsarahm@n005 compilec]$ cat hello.o
ELF>?@@
UH??]?Hello worldGCC: (GNU) 4.8.5 20150623 (Red Hat 4.8.5-44)zRx
K
A?C
?? hello.cmaininputs

???????? .syntab.strtab.shstrtab.rela.text.data.bss.rodata.comment.note.GNU-stack.rela.eh_frame @?0
&PP1P
90\.B?W?R@
?
?0a[brownsarahm@n005 compilec]$ gcc -o hello hello.o -lm
[brownsarahm@n005 compilec]$ ls
hello hello.c hello.i hello.o hello.s
[brownsarahm@n005 compilec]$./hello
Hello world
[brownsarahm@n005 compilec]$ history
1 ls -hw
2 lshw
3 exit
4 ls
5 pwd
6 whoami
7 wget http://www.hpc-carpentry.org/hpc-shell/files/bash-lesson.tar.gz
8 ls
9 tar -xvf bash-lesson.tar.gz
10 ls
11 cat dmel-all-r6.19.gtf
12 head dmel-all-r6.19.gtf
13 tail dmel-all-r6.19.gtf
14 wc -l dmel-all-r6.19.gtf
15 ls
16 wc -l *.fastw
17 wc -l *.fastq
18 wc -l *.fastq > linecounts.txt
19 cat linecounts.txt
20 grep Act5c dmel-all-r6.19.gtf
21 head dmel-all-r6.19.gtf
22 grep mRNA dmel-all-r6.19.gtf
23 grep mRNA dmel-all-r6.19.gtf | wc -l
24 echo "echo 'script works'" >> demo.sh
25 cat demo.sh
26 ./demo.sh
27 ls -l
28 mkdir results
29 ls -l
30 pwd
31 ls /home/brownsarahm
32 cat /home/brownsarahm/demo.sh
33 bash demo.sh
34 ./ demo.sh
35 ./demo.sh
36 chmod +x demo.sh
37 ls -l
38 ./demo.sh
39 nano demo.sh
40 cat demo.sh
41 ls -l
42 nano my_job.sh
43 sbatch my_job.sh
44 squeue --job 23950
45 interactive
46 wall "hello"
47 exit

```

```
50 cat ~/.ssh/authorized_keys
51 rm ~/.ssh/authorized_keys
52 exit
53 ls -a
54 ls -al
55 exit
56 cat /var/log/auth.log
57 exit
58 ls
59 ls .ssh/
60 rm .ssh/
61 ls
62 rm .ssh/authorized_keys
63 ls
64 exit
65 cat .ssh/authorized_keys
66 exit
67 ls .ssh/
68 cat .ssh/authorized_keys
69 cat /var/log/auth.log
70 exit
71 ls
72 pwd
73 whoami
74 wget http://www.hpc-carpentry.org/hpc-shell/files/bash-lesson.tar.gz
75 ls
76 rm *.fastq
77 tar -xvf bash-lesson.tar.gz
78 cat SRR307023_1.fastq
79 head SRR307023_1.fastq
80 tail SRR307023_1.fastq
81 wc -l SRR307023_1.fastq
82 wc -l *.fastq
83 wc -l dmel-all-r6.19.gtf
84 grep Act5c dmel-all-r6.19.gtf
85 grep mRNA dmel-all-r6.19.gtf
86 echo "echo 'script works'" >> demo.sh
87 cat demo.sh
88 echo "echo 'script works'" > demo.sh
89 cat demo.sh
90 ./demo.sh
91 ls -l
92 chmod +x demo.sh
93 ls -l
94 ./demo.sh
95 exit
96 lshw
97 exit
98 interactive
99 grep Act5C dmel-all-r6.19.gtf
100 grep Act5C dmel-all-r6.19.gtf | wc -l
101 grep Act5C dmel-all-r6.19.gtf | head -n 1
102 exit
103 pwd
104 ls
105 mkdir example
106 cd example/
107 pwd
108 mkdir ex2
109 cd ex2/
110 pwd
111 cd
112 ls -l
113 ls -l --block-size=M
114 exit
115 ls
116 ls -a
117 ls .ssh/
118 ls .ssh/authorized_keys
119 ls
120 ls .ssh/authorized_keys
121 ls .ssh/authorized_keys
```

```
124 lshw
125 cat demo.sh
126 ./demo.sh
127 ls my_job.sh
128 cat my_job.sh
129 exit
130 python3
131 exit
132 pwd
133 lshw
134 interactive
135 interactive -t 0:03:00
136 interactive -c 4
137 interactive
138 exit
139 gcc
140 clear
141 exit
142 mkdir compilec
143 cd compilec/
144 ls
145 nano hello.c
146 cat hello.c
147 ls
148 nano hello.c
149 gcc -E hello.c -o hello.i
150 ls
151 cat hello.i | head
152 cat hello.c
153 cat hello.i | tail
154 cat hello.i | wc -l
155 cat hello.c | wc -l
156 gcc -S hello.i
157 ls
158 cat hello.s
159 cat hello.c
160 gcc -c hello.s -o hello.o
161 ls
162 cat hello.o
163 gcc -o hello hello.o -lm
164 ls
165 ./hello
166 ls -la
167 ls
168 rm hello.i hello.s hello.o hello
169 ls
170 gcc --help
171 gcc -Wall -g -o hello hello.c -lm
172 ls
173 nano main.c
174 nano help.c
175 cat main.c
176 cat help.c
177 gcc -Wall -g -c main.c
178 nano main.c
179 cat main.
180 cat main.c
181 gcc -Wall -g -c main.c
182 gcc -Wall -g -c help.c
183 ls
184 gcc -o demo main.o help.o -lm
185 ls
186 ./demo
187 ./demo 6
188 exit
189 interactive
190 exit
191 ls
192 wget http://www.hpc-carpentry.org/hpc-shell/files/bash-lesson.tar.gz
193 ls
194 man tar
195 tar -xvf bash-lesson.tar.gz
```

```
198 man head
199 head dmel-all-r6.19.gtf -n 5
200 tail dmel-all-r6.19.gtf -n 5
201 wc dmel-all-r6.19.gtf
202 man wc
203 wc -l dmel-all-r6.19.gtf
204 ls
205 wc -l *.fastq
206 wc -l *.fastq > linecounts.txt
207 cat linecounts.txt
208 grep Act5c dmel-all-r6.19.gtf
209 grep mRNA dmel-all-r6.19.gtf
210 grep mRNA dmel-all-r6.19.gtf |wc -l
211 exit
212 pwd
213 ls
214 rm *
215 ls
216 whoami
217 interactive
218 exit
219 nano example-job.sh
220 cat example-job.sh
221 man echo
222 bash example-job.sh
223 ./example-job.sh
224 ls -l
225 chmod +x example-job.sh
226 ls -l | grep example
227 ./example-job.sh
228 cp example-job.sh ex2.sh
229 cp example-job.sh ex3.sh
230 cp example-job.sh ex4.sh
231 ls| grep ex
232 ls -l
233 chmod -x ex*.sh
234 ls -l | grep ex
235 ./example-job.sh
236 chmod +x example-job.sh
237 ./example-job.sh
238 nano example-job.sh
239 cat example-job.sh
240 sbatch example-job.sh
241 squeue -u brownsarahm
242 sbatch example-job.sh
243 squeue -u brownsarahm
244 whoami
245 ls
246 cat slurm-27093.out
247 cat slurm-27107.out
248 nano example-job.sh
249 logout
250 cat ex2.sh
251 chmod +x ex2.sh
252 sbatch -J hello -o name-%j ex2.sh
253 nano ex2.sh
254 sbatch -J hello -o name-%j ex2.sh
255 ls |grep name
256 ls |grep name
257 sbatch ex2.sh
258 sysapprovedbadges
259 sysapprovedbadges --help
260 exit
261 logout
262 hostname
263 mkdir compilec
264 rm -rf compilec/
265 mkdir compilec
266 cd compilec/
267 ls
268 nano hello.c
269 cat hello.c
```

```

272 ls
273 cat hello.i |head
274 cat hello.i |tail
275 cat hello.i | wc -l
276 cat hello.i | wc -l
277 cat hello.c | wc -l
278 gcc -S hello.i
279 ls
280 cat hello.s
281 gcc -c hello.s -o hello.o
282 ls
283 cat hello.o
284 gcc -o hello hello.o -lm
285 ls
286 ./hello
287 history
[brownsarahm@n005 compilec]$ ls -l
total 44
-rwxr-xr-x 1 brownsarahm spring2022-csc392 8360 Nov 2 13:27 hello
-rw-r--r-- 1 brownsarahm spring2022-csc392 64 Nov 2 13:12 hello.c
-rw-r--r-- 1 brownsarahm spring2022-csc392 16865 Nov 2 13:14 hello.i
-rw-r--r-- 1 brownsarahm spring2022-csc392 1496 Nov 2 13:23 hello.o
-rw-r--r-- 1 brownsarahm spring2022-csc392 433 Nov 2 13:19 hello.s
[brownsarahm@n005 compilec]$ ls -la
total 48
drwxr-xr-x 2 brownsarahm spring2022-csc392 98 Nov 2 13:27 .
drwx----- 7 brownsarahm spring2022-csc392 4096 Nov 2 13:11 ..
-rwxr-xr-x 1 brownsarahm spring2022-csc392 8360 Nov 2 13:27 hello
-rw-r--r-- 1 brownsarahm spring2022-csc392 64 Nov 2 13:12 hello.c
-rw-r--r-- 1 brownsarahm spring2022-csc392 16865 Nov 2 13:14 hello.i
-rw-r--r-- 1 brownsarahm spring2022-csc392 1496 Nov 2 13:23 hello.o
-rw-r--r-- 1 brownsarahm spring2022-csc392 433 Nov 2 13:19 hello.s
[brownsarahm@n005 compilec]$ nano hello.c
[brownsarahm@n005 compilec]$ cat hello.
cat: hello.: No such file or directory
[brownsarahm@n005 compilec]$ cat hello.c
#include <stdio.h>
void main () {
 printf("Hello world!\n");
}
[brownsarahm@n005 compilec]$./hello
Hello world
[brownsarahm@n005 compilec]$ gcc hello.c
[brownsarahm@n005 compilec]$./hello
Hello world
[brownsarahm@n005 compilec]$ gcc hello.c -lm
[brownsarahm@n005 compilec]$./hello
Hello world
[brownsarahm@n005 compilec]$ ls
a.out hello hello.c hello.i hello.o hello.s
[brownsarahm@n005 compilec]$./a.out
Hello world!
[brownsarahm@n005 compilec]$ gcc hello.c -o hello2
[brownsarahm@n005 compilec]$./hello2
Hello world!
[brownsarahm@n005 compilec]$ gcc hello.c
[brownsarahm@n005 compilec]$ ls
a.out hello hello2 hello.c hello.i hello.o hello.s
[brownsarahm@n005 compilec]$ nano hello.c
[brownsarahm@n005 compilec]$ gcc hello.c
[brownsarahm@n005 compilec]$ ls
a.out hello hello2 hello.c hello.i hello.o hello.s
[brownsarahm@n005 compilec]$./a.out
Hello world! again
[brownsarahm@n005 compilec]$ cat hello.c
#include <stdio.h>
void main () {
 printf("Hello world! again\n");
}

```

[Skip to main content](#)

## 16.1. Prepare for Next Class

No separate preparation, focus on badge work and reviewing the notes if you missed class.

Make sure you did the prep for 10-31, we will work from that on 11/2.

## 16.2. Review today's class

1. create a new ssh key and configure it to your GitHub account
2. Practice using gcc. Repeat steps we did in class, change the order of parameters; try skipping steps to produce errors, etc.  
Then in `gcctips.md` summarize what you learned as a list of tips and reminders on what the parameters do/why/when you would need them (or not). (to reinforce what we learned)

## 16.3. More Practice

1. create a new ssh key and configure it to your GitHub account
2. Install `gcc` locally and practice using it. Repeat steps we did in class on your computer and then change the order of parameters; try skipping steps to produce errors, etc. Export the list of variations you tried and summarize what you learned as a list of tips and reminders on what the parameters do/why/when you would need them (or not) in `gcctips.md`. (to reinforce what we learned)
3. Write two short programs that do the same thing in different ways and compile them both to assembly (eg using a `for` vs `while` loop to sum numbers up to a number). Check the assembly to see if they produce the same thing or if it's different. Save your code (in code blocks) and notes about your findings in `assemblycompare.md`

## 16.4. Experience Report Evidence

## 16.5. Questions After Today's Class

### 16.5.1. What else can we create ssh keys for?

You can use them for GitHub and most developer tools that have authentication provide this option.

### 16.5.2. Why did we need a .i, .s, .o files?

When you build your code, your tools often go from source code to executable without saving the file at the intermediate points. We went through and stopped it at the same

### 16.5.3. How often are SSH keys used by a developer?

I cannot give a specific number, but they are used for remote systems and can be used for GitHub.

## 16.5.4. Why did we not need to do the intermediate steps when we changed the program?

We did not *need* to stop at the intermediate points the first time, we stopped it after each step to look at it, so that we could learn about all of the steps.

We always have the option to do the whole process at once.

## 16.5.5. can you use/import other libraries into seawulf and use them in a program made in seawulf?

Yes. To an extent, there are limits to what you can install, but the basic ones are typically here.

You can see what is there with `module available`

## 16.5.6. When compiling using the following line: `gcc hello.c -o hello` does this remove the .o .s and .i file because it just created the executable file hello?

It does not remove them, but it does skip writing the file *out* at those intermediate points.

## 16.5.7. Are the public and private keys the primes themselves, or are they something derived from the primes?

The product of the primes is part of the public key along with an exponent integer. The two primes are also used to compute the private key. The primes themselves need to be private, but are actually not needed to be known, so they are generally discarded.

## 16.5.8. What are the main uses of doing this?

Understanding the steps of building can help you debug.

## 16.5.9. Will this ever be seen as a better alternative to write code as opposed?

Sometimes the terminal is the fastest tool you have available, like today.

# 17. Linking and Object file binary representation

## 17.1. Why is the linking step important?

Let's make an empty folder to work with. I made my in my `inclass/systems` folder.

```
mkdir cexample
```

and then go in that new folder

```
cd cexample/
```

We are going to make two files, first

```
nano main.c
```

and put this content in the file:

```
/* Used to illustrate separate compilation.
Created: Joe Zachary, October 22, 1992
Modified:
*/
#include <stdio.h>

void main () {
 int n;
 printf("Please enter a small positive integer: ");
 scanf("%d", &n);
 printf("The sum of the first n integers is %d\n", sum(n));
 printf("The product of the first n integers is %d\n", product(n));
}
```

And then make a second file:

```
nano help.c
```

with the contents that describes two functions:

```
/* Used to illustrate separate compilation

Created: Joe Zachary, October 22, 1992
Modified:
*/

/* Requires that "n" be positive. Returns the sum of the
 first "n" integers. */

int sum (int n) {
 int i;
 int total = 0;
 for (i = 1; i <= n; i++)
 total += i;
 return(total);
}

/* Requires that "n" be positive. Returns the product of the
 first "n" integers. */

int product (int n) {
 int i;
 int total = 1;
 for (i = 1; i <= n; i++)
 total *= i;
 return(total);
}
```

```
gcc -Wall -g -c main.c
```

but here we get an error:

```
main.c:8:1: warning: return type of 'main' is not 'int' [-Wmain-return-type]
void main () {
^
main.c:8:1: note: change return type to 'int'
void main () {
^~~~
int
main.c:12:52: error: implicit declaration of function 'sum' is invalid in C99
 [-Werror,-Wimplicit-function-declaration]
 printf("The sum of the first n integers is %d\n", sum(n));
 ^
main.c:13:56: error: implicit declaration of function 'product' is invalid in C99
 [-Werror,-Wimplicit-function-declaration]
 printf("The product of the first n integers is %d\n", product(n));
 ^
1 warning and 2 errors generated.
```

We can get around this, by telling main about the functions by adding

```
int sum(int n);
int product (int n);
```

to the `main.c`

```
nano main.c
```

so that it is like this:

```
/* Used to illustrate separate compilation.
Created: Joe Zachary, October 22, 1992
Modified:
*/
#include <stdio.h>
int sum(int n);
int product(int n);

void main () {
 int n;
 printf("Please enter a small positive integer: ");
 scanf("%d", &n);
 printf("The sum of the first n integers is %d\n", sum(n));
 printf("The product of the first n integers is %d\n", product(n));
}
```

Now we can make this object file

```
gcc -Wall -g -c main.c
```

```
main.c:10:1: warning: return type of 'main' is not 'int' [-Wmain-return-type]
void main () {
^
```

[Skip to main content](#)

```
~~~~~  
int  
1 warning generated.
```

we get a warning, but that's okay

```
ls
```

```
help.c main.c main.o
```

If we try to make this an executable, we cannot because then it looks for what those functions are supposed to do, but it cannot do that yet.

```
gcc -o demo main.o -lm
```

```
Undefined symbols for architecture x86_64:  
  "_product", referenced from:  
    _main in main.o  
  "_sum", referenced from:  
    _main in main.o  
ld: symbol(s) not found for architecture x86_64  
clang: error: linker command failed with exit code 1 (use -v to see invocation)
```

So, we make the object file for the helper functions

```
gcc -Wall -g -c help.c
```

Now, we can finally link and make it executable:

```
gcc -o demo main.o help.o -lm
```

and we can run our program

```
./demo
```

```
Please enter a small positive integer: 5  
The sum of the first n integers is 15  
The product of the first n integers is 120
```

### 💡 Tip

One reason we split code is to make it readable, but another reason is what we just did. We can compile each file separately, when your code is large and compiling takes a long time, splitting it will mean you only have to recompile the file(s) you have recently changed and relink, instead of recompiling everything.

If we edit,

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```
nano main.c
```

to look like the following:

```
/* Used to illustrate separate compilation.  
Created: Joe Zachary, October 22, 1992  
Modified:  
*/  
  
#include <stdio.h>  
int sum(int n);  
int product(int n);  
  
void main () {  
    int n;  
    printf("Hello! Please enter a small positive integer: ");  
    scanf("%d", &n);  
    printf("The sum of the first n integers is %d\n", sum(n));  
    printf("The product of the first n integers is %d\n", product(n));  
}
```

We added an ! so it is just different.

If we run again, it is not different.

```
./demo
```

```
Please enter a small positive integer: 7  
The sum of the first n integers is 28  
The product of the first n integers is 5040
```

Now, we need to recompile the main file.

```
gcc -Wall -g -c main.c
```

```
main.c:10:1: warning: return type of 'main' is not 'int' [-Wmain-return-type]  
void main () {  
^  
main.c:10:1: note: change return type to 'int'  
void main () {  
^~~~  
int  
1 warning generated.
```

and then relink them into an executable

```
gcc -o demo main.o help.o -lm
```

for the changes to apply

```
./demo
```

```
The sum of the first n integers is 36
The product of the first n integers is 40320
```

We see that this makes the executable and the two object files

```
ls -la
```

```
total 136
drwxr-xr-x 7 brownsarahm staff 224 Nov 7 12:53 .
drwxr-xr-x 9 brownsarahm staff 288 Nov 7 12:37 ..
-rwxr-xr-x 1 brownsarahm staff 50072 Nov 7 12:53 demo
-rw-r--r-- 1 brownsarahm staff 474 Nov 7 12:40 help.c
-rw-r--r-- 1 brownsarahm staff 2364 Nov 7 12:49 help.o
-rw-r--r-- 1 brownsarahm staff 383 Nov 7 12:52 main.c
-rw-r--r-- 1 brownsarahm staff 2400 Nov 7 12:53 main.o
```

We can change the name of the executable with the `-o` option.

```
gcc -o sumProd main.o help.o -lm
```

```
./sumProd
```

```
Hello! Please enter a small positive integer: 8
The sum of the first n integers is 36
The product of the first n integers is 40320
```

```
cat help.o
```

```
????8 ??X?
__text__TEXT~X?__debug_str__DWARF~??__debug_abbrev__DWARFCZ?__debug_info__DWARF???__apple_names__DI
h__debug_line__DWARF??H      2

'
PUH??}??E??E?;E??E?E?E????E??????E?]?UH??}??E??E?E?;E??E?E?E????E??????E?]?Apple
;          'I?:;
;          I4:;
;          I$>

?
/6ju-=V?
??|?
??x?
?

???????
F?7?8H?2?vHSah
????HSah
????HSah
0??
4??$=@>zRx
?$X??????=A?C
help.c????>A?C
v      ut<<
```

[Skip to main content](#)

\_product\_sum` `` g <s? Z<w3& +@

```
```{code-cell} bash
:tags: ["skip-execution"]
cat ~/.bash_profile
```

```
alias pip=python3
alias python=python3

export PS1="\u@\W \$ "

# >>> conda initialize >>>
# !! Contents within this block are managed by 'conda init' !!
__conda_setup=$(('/Users/brownsarahm/anaconda3/bin/conda' 'shell.bash' 'hook' 2> /dev/null)|
if [ $? -eq 0 ]; then
    eval "$__conda_setup"
else
    if [ -f "/Users/brownsarahm/anaconda3/etc/profile.d/conda.sh" ]; then
        . "/Users/brownsarahm/anaconda3/etc/profile.d/conda.sh"
    else
        export PATH="/Users/brownsarahm/anaconda3/bin:$PATH"
    fi
fi
unset __conda_setup
# <<< conda initialize <<<
```

python

```
b'\x00\x00\x00'  
>>> bytes(bytarray(2))  
b'\x00\x00'  
>>> name_ints = [ord(char) for char in name]  
>>> with open('name.txt', 'wb') as f:  
...     f.write(bytes(bytarray(name_ints)))  
...  
5  
>>> with open('name.txt', 'wb') as f:  
...     f.write(bytes(bytarray(name_ints)))  
...  
5  
>>> exit()
```

```
ls
```

```
demo           help.o        main.o        sumProd  
help.c         main.c        name.txt
```

```
cat name.txt
```

```
sarah```
```

```
```{code-cell} bash  
:tags: ["skip-execution"]  
python
```

```
Python 3.11.4 (main, Jul  5 2023, 09:00:44) [Clang 14.0.6 ] on darwin  
Type "help", "copyright", "credits" or "license" for more information.  
>>> name = 'sarah'  
>>> name_ints = [ord(char) for char in name]  
>>> name_ints = [ord(char)+5 for char in name]  
>>> with open('name.txt', 'wb') as f:  
...     f.write(bytes(bytarray(name_ints)))  
...  
5  
>>> exit()
```

```
cat name.txt
```

```
xfwfm```
```

```
```{code-cell} bash  
:tags: ["skip-execution"]  
python
```

```
Python 3.11.4 (main, Jul  5 2023, 09:00:44) [Clang 14.0.6 ] on darwin  
Type "help", "copyright", "credits" or "license" for more information.  
>>> name_ints = [ord(char)-100 for char in name]  
Traceback (most recent call last):  
  File "<stdin>", line 1, in <module>  
NameError: name 'name' is not defined  
>>> name = 'sarah'  
>>> name_ints = [ord(char)+200 for char in name]
```

[Skip to main content](#)

```

...
Traceback (most recent call last):
  File "<stdin>", line 2, in <module>
ValueError: byte must be in range(0, 256)
>>> with open ('name.txt', 'rb') as f:
...     content = f.read()
...
>>> content
b''
>>> name_ints = [ord(char)-32 for char in name]
>>> with open('name.txt','wb') as f:
...     f.write(bytes(bytarray(name_ints)))
...
5
>>> with open ('name.txt', 'rb') as f:
...     content = f.read()
...
>>> content
b'SARAH'
>>> type(content)
<class 'bytes'>
>>> bin(115)
'0b1110011'
>>> char(d)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'char' is not defined. Did you mean: 'chr'?
>>> int('4')
4
>>> a = '4'
>>> type(a)
<class 'str'>
>>> type(int(a))
<class 'int'>
>>> msg = [68, 114, 46, 32, 66, 114, 111, 119, 110,10]
>>> bytes(bytarray(msg))
b'Dr. Brown\n'
>>> exit()

```

## 17.2. Prepare for Next Class

1. Review your IDE notes (or complete them if you have not yet) `ide_thoughts`.
2. Think about what features or extensions in your favorite IDE you like the most and that you think others may not know about.

## 17.3. Review today's class

3. Create some variations of the `hello.c` we made in class. Make `hello2.c` print twice with 2 print commands. Make `hello5.c` print 5 times with a for loop and `hello7.c` print 7 times with a for loop. Build them all on the command line and make sure they run correctly.
4. Write a bash script, `assembly.sh` to compile each program to assembly and print the number of lines in each file.
5. Put the output of your script in `hello_assembly_compare.md`. Add to the file some notes on how they are similar or different based on your own reading of them.

## 17.4. More Practice

On Seawulf, modfiy `main.c` from class to accept the integer as a command line argument instead of via input while running the program. See this tutorial for an example. 5. Write a bash script `demo_test.sh` that runs your compiled program for each integer

script on a compute node and save the output to a file. The sbatch script should compile and link the program and then call the script. [see the options](#) 7. use `scp` to download your modified main, script files, and output to your local computer and include them in your kwl repo.

## 17.5. Experience Report Evidence

## 17.6. Questions After Today's Class

### 17.6.1. Why didn't python work locally for me?

On Windows, you may need to reinstall GitBash with different settings.

### 17.6.2. Can I get a bunch of binary representations of letters and use it to write to a file in characters?

yes

### 17.6.3. Are we implementing more function/loops in the future?

More can be done, but not a lot more in class time

### 17.6.4. What would be a case where we need to use bytes conversion in our code?

If you need to compress data to work in a low memory environment.

### 17.6.5. Why would I want to write and compile code from a Terminal and not from an IDE?

If you are working on a server where you do not have an IDE available. Or if you are doing something really quick.

### 17.6.6. Is it ok that I see blobs in the object file, not just od characters?

Yes! Different computers will make different amounts of progress at this

### 17.6.7. what else can i do with c / python in the terminal

You can do anything the language can do through a terminal. We had programming before we had modern IDEs.

### 17.6.8. Does the order of the compiling command matter?

This is a practice badge question.

### 17.6.9. What benefit is it to create python scripts on the server?

If it is processing large amount of data or if it has complex calculations that are intensive.

### 17.6.10. Is there a way to view a text file in raw bytes with a bash command?

the terminal cannot show it as the raw bytes, but we will see some ways to view the file in different representations.

### 17.6.11. Is it better to use python in the terminal?

it is not better, it is just another option. Having more options also helps you see the how it really works.

### 17.6.12. Most people will tell you python is extremely slow, so why are we still using it?

Python is slower than C, but it is much easier to read than fast languages. So it is often faster to write. It also has more effective, well written libraries and consistent performance. It is essentially the only option for modern effective AI models unless you are writing it all from scratch which is generally intractable.

## 17.7. Good Explore badge questions

- how would linking a third file to the executable affect how it runs, if it has nothing to do with the rest of the code

## 18. What is an IDE?

Work through the following on your own or in groups in class.

If in class, make sure to stop at 1:35 to leave extra time for the experience report, because it is a little longer than the regular in class experience badges.

### 18.1. Review your notes

#### Important

Do this before proceeding to the next section. The x.y are sections and the x.y.z are subsections.

Either discuss with peers in class or on the GitHub (asynch) discuss commonalities in your IDE notes.

#### Note

Spend 15-20 minutes on this

#### 18.1.1. In person

2. What features of an IDE did you all use?
3. Which features were used but not very much?
4. Share the most helpful IDE feature you use?

Update your individual IDE notes with 1-2 things you learned from your peers. Include this updated file in your experience report.

## 18.1.2. On GitHub

There are questions on the [GitHub Discussion](#). Update your individual IDE notes in your KWL repo with links to your post and replies.

## 18.2. Learn more

### Note

This should take the majority of class time. Spend 30-40 minutes on this.

- What is an IDE?
- compare IDEs
- Most popular in 2021
- Most popular in 2022

### 18.2.1. In person

In class with your peers you can divide these up and read one and then share key points with others.

With your group, build a large list of IDE attributes or features that would be important, and make a table of how would you evaluate attribute? Which ones would you evaluate by just if it exists or not? Which ones would you evaluate in different degrees, what attributes of them would you evaluate?

Discuss with your group how you would rank them. You do not all have to agree on a final ranking, but notice the differences.

[vs code is open source](#)

Have one member of the group summarize what your group discussed [on GitHub](#) for your classmates. Note the ranking, with any disagreements. Include your group members by @ mentioning them.

### 18.2.2. Asynchronous

After reading the above, also read at least 3 different articles or blog posts about the “best IDE” for your favorite language or for multiple languages.

Notice what IDE attributes or features the authors think is important, and how they evaluate each criterion. Which ones are evaluated as present/missing? Which ones are evaluated in more detail.

Join the discussion on [on GitHub](#) summarizing what you found the most important criteria to be and if you personally agree or not.

[Skip to main content](#)

## 18.3. Features and Extensions

### Note

Skip this if the above runs over time, otherwise spend a few minutes preparing and then only 2-3 minutes per student demo-ing your feature or extension.

If in class, share your favorite IDE features or extensions to get a head start on your practice badge.

Think about how I modeled the multi-cursor feature in class.

Optional: Try using the Air media to demo it.

## 18.4. Experience Reports

For today, whether you are in class or asynchronous use the experience report (makeup) action. Use ISO date format: YYYY-MM-DD for the workflow input.

## 18.5. Prepare for Next Class

Review the prep from 2023-11-07 or do it if you have not.

## 18.6. Review today's class

1. Try a new IDE and make some notes about how it was to learn in newide.md What is easy? hard? What could you apply from the ones you already use? Were there features you had trouble finding?
2. Add at least one comment on others' posts on the [GitHub discussions](#) about IDEs.

## 18.7. More Practice

The first three tasks are the practice task, Option A and Option B are pre-approved explore badges. Hover over one of them on your issue to create an independent issue to track it. Title the new issue `Explore: IDE-X` where X is A or B based on your choice. On the explore badge, when it is ready for submission, request a review from Dr. Brown.

1. Examine the IDE you use most and add frequentide.md to your kwl with notes about which features it does/not have based on what you learned in the in-class activity.
2. Try a new IDE and make some notes about how it was to learn in newide.md What is easy? hard? What could you apply from the ones you already use? Were there features you had trouble finding?
3. Add at least one comment on others' posts on the [GitHub discussions](#) about IDEs.
4. (option A) Compare at least 3 IDEs for working in a single language. Your comparison should be based on first hand experience using each of the IDEs. Complete the same task in each tool. Create `favoriteide.md` to define and justify your preferred IDE. Describe the procedure you did to compare the IDEs. Include a ranked list of your criteria(which attributes and features) with justification/explanation of your ranking of these criteria. Then describe how each of the three IDEs meets/does not meet those criteria, and a conclusion of which IDE is the best based on your criteria.

5. (option B) Create a small repo owned by introcompsys named `ide-USERNAME` where `USERNAME` is your gh username with some example code, a vscode/codespace `devcontainer` file that installs `CodeTour` and your favorite extension(s). Write a `CodeTour` that walks someone through using your favorite extension to do something with the code. The example code can be any language, can be very simple, can even have a bug in it if that helps your example. You can use an LLM to generate some code for this purpose if you do not have some available to you already, but you cannot share solutions to a course assignment without that instructor's permission. Link to your repo in your

## 18.8. Questions After Today's Class

Will be gathered from your experience reports.

# 19. What happens when we run code?

Today we are going to use a CPU emulator to see what happens when we run code. This also lets us start to learn some of the components in a computer in a little bit more detail.

## 19.1. Start the emulator

For more on how the emulator works see the [CPU Emulator Tutorial](#).

For much more detail about how this all works chapter 4 of the related text book has description of the machine code and assembly language.

[Mac/Linus](#)    [Windows](#)

## 19.2. Load a program

We're going to use the test cases from the book's project 5:

1. File
2. Load Program
3. Navigate to nand2tetris/projects/05
4. select add.hack
5. click load ROM

We're not going to *do* project 5, which is to build a CPU, but instead to use the test.

## 19.3. How does the computer actually add constants?

This program adds constants, 2+3.

It is a program, assembly code that we are loading to the simulator's ROM, which is memory that gets read only by the CPU.

- address register
- program counter
- ALU
- ROM
- RAM

Run the simulator and watch what each line of the program does.

Notice the following:

- to compute with a constant, that number only exists in ROM in the instructions, it does not ever get written to RAM
- to write a value to memory the address register first has to be pointed to what where in the memory the value will go, then the value can be sent there

For more detail section 5.2.1- 5.2.6 of nan2tetris book

- This program the first instruction puts 2 in the address register from the instructions in ROM.
- Then it moves the 2 through the ALU to the data register (D)
- then it puts 3 on the address register
- then it adds the numbers at D and A
- then it puts 0 on the address register
- then it write the output from the ALU (D) to memory (at the location indicated by the A register)

## 19.4. High level code

This code is equivalent to:

```
x = 2+3
```

or

```
int x = 2+3
```

Specifically note:

- this program does *not* put the 2 and 3 into RAM before adding them
- it stores the result, but does not print it

## 19.5. Modifications to try

- Change the program to add 3+4
- Change the program to store the result in memory location 16 instead of 0
- Change the program to store the two numbers to RAM first, then add them.

Create some experiments in the simulator and write new programs. Here are some ideas, but you can try anything you are curious about.

- What line do you change to change where it outputs the data?
- How could you add a third number?
- How could you add two pairs, saving the intermediate numbers?
- How could you do  $(4+4)*(3+2)$ ?

## 19.7. Be careful with variable names

### ⚠ Warning

This was a bit of a tangent, but is a useful to know thing

python

```
Python 3.11.4 (main, Jul  5 2023, 09:00:44) [Clang 14.0.6 ] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> sum([3,4])
7
>>> sum =3+4
>>> sum([3,4])
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'int' object is not callable
>>> sum
7
>>> exit()
```

If we assign `sum` as a variable, Python lets us even though `sum` is a builtin function.

then, we cannot use the `sum` funciton again until we restart the interpreter.

python

```
Python 3.11.4 (main, Jul  5 2023, 09:00:44) [Clang 14.0.6 ] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> sum([3,4])
7
>>> sum_ =3+4
>>> sum([3,4])
7
>>> my_sum =3+4
>>> exit()
```

## 19.8. Prepare for Next Class

1. Refresh your knowledge of logical operations/ logic gates: and, or, xor, not. For an example reference see the logicemu emulator we will use in class

## 19.9. Review today's class

1. Run and examine how rect.hack and max.hack in the [nand2tetris/projects/05/](#) folder work. Make notes and answer the questions below in assemblyexplore.md.

1. Explain how `max.hack` works `in` detail.
2. Write code `in` a high level language that would `compile` into this program.
3. What does this `max.hack` assume has happened that it doesn't `include` in its body?

## 19.10. More Practice

1. Run and examine how rect.hack and max.hack in the [nand2tetris/projects/05/](#) folder work. Make notes and answer the questions below in assemblyexplore.md.

1. What does rect.hack do?
2. What did you learn trying to figure out how it works?
3. Explain how max.hack works in detail.
4. Write code in a high level language that would compile into this program. Try writing multiple different \
5. What does this max.hack assume has happened that it doesn't include in its body?

## 19.11. Experience Report Evidence

Add in your experience report the modifications to the code as above.

## 19.12. Questions After Today's Class

### 19.12.1. Will there be a detailed breakdown of today's class in the notes?

It's an overview, but there are links to the textbook chapter for more detail. If you have a specific question, open an issue and I can add that specific detail here.

### 19.12.2. Can this be used for more than just seeing how things get stored in memory?

You can use the emulator for also testing how this type of assembly code works.

### 19.12.3. Why are the roms .hack files?

This CPU is a simplified CPU that is just the essentials for the sake of learning. Hack is the name of the machine language that this CPU uses.

### 19.12.4. What would you say is the most complex operation a CPU can do?

This is a hard question. The CPU does all of the things that our computers do other than the actual display and input. However, what is the most complex single instruction, is a little bit more clear.

We can think of complexity in different ways, but I will, for the sake of this answer, say that the largest circuit is the most complex. In that case, it is probably multiplication.

### 19.12.5. Does the process become more complex with more processors?

The base is the same, but there are added steps to schedule and assign work to separate processors.

### 19.12.6. Are there more than one ALUs in modern CPUs? If so, does the number have some relation to the number of CPU cores or threads?

Yes, CPU “cores” are roughly equivalent to ALUs. Occasionally there are additional ALUs that are used as if they are simpler because of the way mass production and economy of scale works...

Threads are a software level abstraction. The number of threads that execute in parallel truly is the one per core, but you can have more threads than cores, and they'll get scheduled partially in parallel and partially in sequence.

### 19.12.7. What is the CPU Emulator

It is a program that is designed to simulate what happens in a CPU which is the central processing unit of a computer.

### 19.12.8. what do the first two lines of rect.hack do?

`@0` puts 0 in the address register. `D=M` loads the value from the memory location indicated in the address register to the D register. Together this means that it loads the value of the RAM at location 0 to the D register.

## 20. How can we use logical operations?

### 20.1. Why do we need to think about bitwise operations?

Understanding them is prereq to what we will see today and that will help you understand hardware overall.

You of course will not *need* every single thing we teach you in every single class.

- Seeing topics once at least is the only way you can make an informed decision to study a topic deeper or not.
- Seeing a topic in more detail than you will use all the time actually helps you build intuition, or deep understanding, of the topic overall, and help you remember what you need to remember

### 20.2. Bitwise operators review

- & : and
- | : or
- ^ : xor
- ~ : not

-  : shift right
- <<: shift left

Let's review truth tables for and, or, and xor.

*Table 20.1 AND*

a	b	AND (a&b)
0	0	0
0	1	0
1	0	0
1	1	1

*Table 20.2 OR*

a	b	OR (a b)
0	0	0
0	1	1
1	0	1
1	1	1

*Table 20.3 XOR*

a	b	XOR (a^b)
0	0	0
0	1	1
1	0	1
1	1	0

In order to implement more complex calculations, using gates, we can use these tables as building blocks compared to the required output.

There are more gate operations; you can see a simulation for 16 gates

## 20.3. Adding as an Algorithm

**remember, binary is a place-based system like the decimal placed based system you are likely familiar with**

How do you add each of the following:

- $2 + 3$
- $14 + 17$
- $65 + 37$

To add two or more digit numbers we add the right most place (ones) and if its' more than 10, we carry the 1 then add 3 numbers (1 and the other two digits). And proceed accordingly moving from right to left.

Since binary is place-based adding with binary follows the same basic algorithm

- add the two bits in the ones place
- carry to the next place if  $\geq 2$

$$101 + 100 = 1001$$

We first add the ones place and get a 1, then the two's place and get a zero then the 4's place and get 0 with a carried one.

$$010 + 011 = 101$$

In this case in the ones place we add  $0 + 1$  to get one, the two ones add to 0 with carry then  $1 + 0 + 0$  gives another 1.

## 20.4. Adding as logic gates

let's make a truth table for adding two bits.

Table 20.4 Add

a	b	out 2's	out 1's
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Now, what gate can we use to get the output 1's place bit and what gate can we use to get the output 2's place bit by comparing to the truth tables above.

It turns out the one's place is an xor gate, and the two's place is an and gate.

This makes up the half adder, try one out at this simulator.

## 20.5. Implementing the carry

So this lets us add two bits, but what about adding a number with more bits?

[Skip to main content](#)

We can put multiple together, but there's one more wrinkle: the carry.

That's what makes a [full adder](#) different. It adds three single bits, or a carry and two bits and outputs the result as a sum bit and a carry bit.

## 20.6. Adding more bits

Then we can link many of those together to get an [8 bit ripple adder](#).

Alternatively, we can "lookahead" with the carry bit, passing it forward multiple places all at once, as shown in this [4 bit carry lookahead adder](#).

## 20.7. Why do this?

Working through this example also reinforces not only the facts of how the binary works so that you can understand *how* a computer works. Working with these abstractions to break down higher level operations into components like this (addition is a more complex operation than [and](#) or [xor](#)) help you see how this can be done.

Sometimes you have low level problems like resource constraints and bitwise operations can be useful.

We may not do this all the time, but when we need it, we need it.

for example, consider how to swap two values.

Assume we have two variables [a](#) and [b](#) initialized like:

```
a = 4  
b=3  
a, b
```

```
(4, 3)
```

We could swap them like

```
tmp = a  
a = b  
b=tmp
```

then we can see the values to see that they are swapped

```
a, b
```

```
(3, 4)
```

Let's reset them

```
a =4  
b=3  
a,b
```

(4, 3)

With bitwise operations we can swap them without a 3rd variable.

```
a = a^b  
b= a^b  
a=a^b
```

then we can see the values to see that they are swapped

```
a,b
```

(3, 4)

If we implement this with only 3 bits we have a 1,2,4 places.

A

1

0

0

B

0

1

1

Then we xor each bit and store the result in the first register (our a variable)

A

1

1

1

B

0

1

1

and next we xor again and store in b

A

1

1

1

B

1

0

0

now the 4 has moved from A to B. If we xor one more time and store that in A,

A

0

1

1

B

1

0

0

## 20.8. Prepare for Next Class

1. In fractionalbinary.md use 8 bits to represent the following numbers by using 4 bits as usual (8,2,4,1) and the other 4 bits are 1/2, 1/4, 1/8, 1/16th:
  - 3.75
  - 7.5
  - 11.625
  - 5.1875
1. Add to your file some notes about the limitations of representing non integer values this way. How much would using more bits help with, what limitations are not resolved by adding more bits. For example, how could you represent .1?

## 20.9. Review today's class

1. While we saw many types of gates today, but we actually could get all of the operations needed using only NAND gates. Work out how to use NAND gates to implement `and` and `or` in nandandor.md
2. Add bitwise.md to your kwl and write the bitwise operations required for the following transformations (replace the `(_)` with a bitwise operator (`&`, `|`, `^`, `>>`, `<<`)):

```
4 (_ ) 128
12493 (_ ) -12494
127 (_ ) 15
7 (_ ) 56
4 (_ ) -5
45 (_ ) 37 = 37
45 (_ ) 37 = 45
```

[Skip to main content](#)

```
6 (...) 8 = 0
10 (...) 5 = 15
```

## 20.10. More Practice

1. While we saw many types of gates today, but we actually could get all of the operations needed using only NAND gates. Work out how to use NAND gates to implement a half adder and describe it in nandhalf.md
2. In addertypes.md compare ripple adders and lookahead adders.

```
1. Give a synopsis of each adder type
1. Compare them in terms of time (assume that each gate requires one unit of time)
1. Compare them in terms of space/cost by counting the total number of gates required.
```

3. Add bitwise.md to your kwl and write the bitwise operations required for the following transformations (replace the `(...)` with a bitwise operator (`&, |, ^, >>, <<, ~`):

```
4 (...) 128
12493 (...) -12494
127 (...) 15
7 (...) 56
4 (...) -5
45 (...) 37 = 37
45 (...) 37 = 45
3 (...) 5 = 7
6 (...) 8 = 0
10 (...) 5 = 15
```

## 20.11. Experience Report Evidence

Nothing separate

## 20.12. Questions After Today's Class

### 20.12.1. How often will we be using the emulator moving forward?

We will use the logic emulator a few more times.

### 20.12.2. What other bitwise operations are there that do more efficient things like swap the values of two variables?

This is a good explore badge idea

### 20.12.3. How much of a disadvantage (*performance wise*) is using the gates that are changed to fit economies of scale vs the simplifies versions?

Calculating this out is a good way to extend the practice badge today into an explore badge.

## 20.12.4. Could you do any mathematical operation with bitwise operations like square root, cubed root, division, etc?

We can break anything down into bitwise operations. Some are more complicated than others, but all the computer has is bitwise operations, so everything can be done with those.

## 20.12.5. How would we implement this in code?

This is how the computer implements your code as electrical activity.

If the question is only about the XOR swap algorithm, I put real python code in the notes.

## 20.12.6. Are the circuits and gates the things inside a processor?

Yes the processor contains circuits made up of gates.

## 20.12.7. Is it common to use tricks like the one above in embedded systems?

Yes

## 20.12.8. Why is this so confusing and how can I understand how to do these operations better?

More practice and maybe office hours?

It is confusing because it is new.

## 20.13. Will this be extremely useful if we started working with computers at its very foundation? (Physics, Discrete Math etc.)

Yes! That is the type of cases where bitwise operations are the level that you reason at.

# 21. How does a computer represent non integer quantities?

So far we have looked at how computers represent integers in binary and how it can do math using logic gates.

A lot of operations we do require representing quantities that are not whole numbers.

## 21.1. Let's Try a Fixed point

Let's experiment with an 8 bit representation with 1 bit for sign and then the next 4 used for the part of the number greater than 0 and the last 3 for the fractional part.

so then the number:

would be interpreted like:

0 - 1000 . 001

positive, 8.1

in this then we can represent the numbers 0-8 for the right hand side and 0-15 on the left hand side so we get

```
import itertools
num_list = [str(n) + '.' + str(f) for n, f in itertools.product(range(16), range(8))]
', '.join(num_list) + ', '.join(['-' + n for n in num_list])
```

'0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5

That is it, all the numbers we can represent in this way.

```
len(num_list)*2
```

256

## Important

## correction

It is still the same number of values, but they're spread out differently

The integers would be spread out uniformly, but these are not.

( $2^{**}7$ ) $^{*}2$

256

## 21.2. Binary fractions

What if instead, we could represent numbers with a fixed point, is to use base two fractions, just like we represent numbers in decimal. Instead of the points to the right of the decimal being the  $\frac{1}{10}, \frac{1}{100}, \frac{1}{1000}$  they are the  $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$  etc.

In this fixed point we would have, for example: `0101.1010` would be \$

$$0 * 2^3 + 1 * 2^2 + 0 * 2^1 + 1 * \frac{1}{2^{-1}} + 0 * \frac{1}{2^{-2}} + 1 * \frac{1}{2^{-3}} + 0 * \frac{1}{2^{-4}} = 4 + 1 + \frac{1}{2} + \frac{1}{8} = 5 + \frac{5}{8} = 5.625\text{\$}$$

In this case we still have a small set of numbers, but it's a different set of possible numbers.

We can write numbers in many different forms. We have written integers through many different bases so far.

For example in scientific contexts, we often write numbers (in base 10) like:

$$3.45 \times 10^2 = 345$$

or

$$3.45 \times 10^{-2} = .0345$$

Sometimes, we shorten these to `3.45e2` for short.

In math, we do not have to block out how many place values we are going to use in advance explicitly, but to build a computer we do. So we have to decide how many bits we will use and how to use each one of them.

## 21.4. Floating point numbers are not all exact

Before we dig into the details, let's review why this matters.

Julia Evans asked people on Mastodon for examples how floats do weird things and then wrote a blog post summarizing eight examples, and the link to the mastodon thread with even more replies.

She also wrote a zine with complementary resources. If you would like a print copy of the zine, email Dr. Brown.

Let's look at an example, we add `.1` together 3 times, and we get the expected result.

```
.1 + .1 + .1
```

```
0.30000000000000004
```

However, if we check what it's equal to, it does not equal `.3`

```
.1 + .1 + .1 == .3
```

```
False
```

This is because the floating point representation is an *approximation* and there are multiple full numbers that are close to any given number that cannot be expressed exactly. However, the display truncates since usually we want only a few significant digits.

Even rounding does not make it work.

```
round(.1,1) + round(.1,1) + round(.1,1) == round(.3,1)
```

```
False
```

Now, let's see how these numbers are actually represented.

[IEEE Floating Point](#) is what basically everyone uses, but it is technically a choice hardware manufacturers can technically make.

- Initially proposed in 1985
- Revised in 2008 after 7 year process that expanded
- revised in 2019 after 4 year process that mostly clarified

*IBM mainframes use their own representation based on Hex*

Next revision is projected to 2028.

It includes specifications for using varying numbers of bits. In different programming languages different types are represented with different standards.

In C/C++ for example, floats are single precision floating point numbers or using 32 bits. `double` is double precision, using 64 bits.

In python, `float` is 64 bit on a 64 bit computer.

In Javascript, there are no integers, only floats with the precision specified by the architecture.

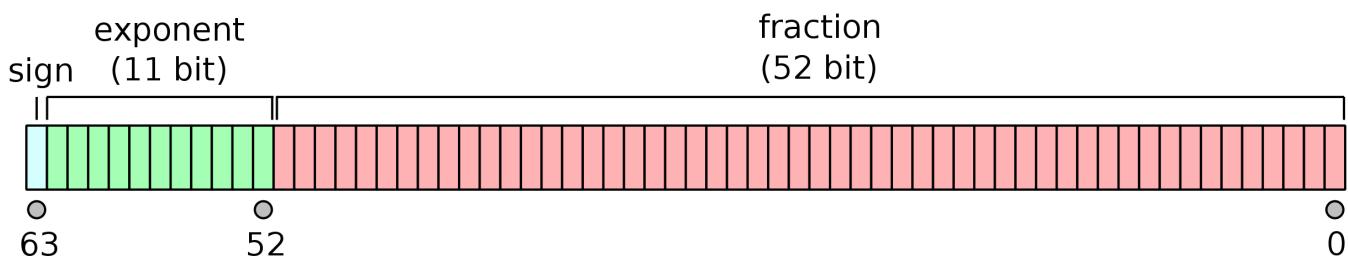
### 21.5.1. Double Standard

This is a double precision float or binary64 in the current standard.

It was called double in the original, officially, so it is commonly called that.

In this case we will use:

- 1 bit for sign
- 11 bits for exponent and
- 52 bits for the fraction part



### 21.5.2. How do we read a number like this?

If the sign bit is  $s$  and the number represented by the exponent bits is  $e$  and the 52 bits are number from right most is 0 and the last one is 52.

Then we read it as a value like:

Note that this is  $2^{-i}$  so we are working with fractions instead of integers in the sum.

So if we had:

it would represent:

$$(-1)*0 + (1 + 0 \cdot 2^{-1} + \dots + 0 \cdot 2^{-51} + 0 \cdot 2^{-52}) \times 2^{1023-1023} = 0 + (1+0) \times 2^0 = 1 \times 1 = 1.0$$

In English:

- the sign bit is zero, so it is a positive number
  - the exponent is 1023, so we end up multiplying by 1
  - the fraction bits represent 0, so we end up with just the 1 in the equation

## visualized

and

would represent: \$

$$(-1)*0 + (1 + 0 \cdot 2^{-1} + 1 \cdot 2^{-2} + 0 \cdot 2^{-3} + \dots + 0 \cdot 2^{-51} + 0 \cdot 2^{-52} \times) 2^{1023-1023} = 0 + (1 + \frac{1}{2}) \times 2^0 = 1.5 \times 1 = 1.$$

\\$

You can see this visually using float exposed

 Tip

the URL of that link is to <float.exposed/0x3ff4000000000000>

`3ff4000000000000` is the number we want to view in hex. Since the first 12 bits of the 64bit number are the sign and exponent, the first 3 characters represent those then the remaining 13 characters represent the 52 bits of the fraction.

Python can give you the hex representation of a float:

```
float.hex(1.25)
```

'0x1.40000000000000p+0'

This matches what we saw above, but it takes some re-arranging, this is a good practice.

### 21.5.2 How do we get numbers into this form?

[Skip to main content](#)

Now, let's return to our example of .1.

First we take the sign of the number for the sign bit, but then to get the exponent and fraction, we have more work to do.

To figure this out, we'll start by manipulating the format that we need to get our number into:

$$\left(1 + \sum_{i=1}^{52} b_{52-i} 2^{-i}\right) \times 2^{e-1023}$$

If we think about the fraction and how we add fractions, by reaching a common denominator. Since they're all powers of two, we can use the last one as our common denominator:

$$\left(1 + \sum_{i=1}^{52} b_{52-i} 2^{-i}\right) \times 2^{e-1023} = \left(1 + \frac{b_{52}}{2^1} + \frac{b_{51}}{2^2} + \dots + \frac{b_1}{2^{51}} + \frac{b_0}{2^{52}}\right) \times 2^{e-1023}$$

Now with a common denominator:

$$\left(\frac{2^{52}}{2^{52}} + \frac{2^{51}b_{52}}{2^{52}} + \frac{2^{50}b_{51}}{2^{52}} + \dots + \frac{2^1b_1}{2^{52}} + \frac{2^0b_0}{2^{52}}\right) \times 2^{e-1023}$$

$$\left(\frac{2^{52} + 2^{51}b_{52} + 2^{50}b_{51} + \dots + 2^1b_1 + 2^0b_0}{2^{52}}\right) \times 2^{e-1023}$$

So then we can treat the numerator as a binary number with 53 bits (the  $52 + 1$ ) let's call that number  $J$ .

$$\frac{J}{2^{52}} \times 2^{e-1023}$$

we can then combine the powers of 2 and we'll call that exponent  $N$

$$\frac{J}{2^{52-e+1023}} = \frac{J}{2^N}$$

So in order to return to our [.1](#) that we want to represent, we can represent our target number as a fraction and then estimate it in the form above.

$$\frac{1}{10} \approx \frac{J}{2^N}$$

let's isolate  $J$  by multiplying both sides by  $2^N$

$$J \approx \frac{2^N}{10}$$

We want to use exactly 53 bits to represent  $J$  because it needs to be represented by the part of the float standard that is  $1 + \sum_{i=1}^{52} b_{52-i} 2^{-i}$ . Which is 52 bits that can be either 0 or 1, plus the left most bit is a fixed 1 from the  $1+$  in the definition.

we want  $J \approx \frac{2^N}{10}$  to be greater than or equal to  $2^{52}$  and less than  $2^{53}$ , or equivalently:

$$2^{52} \leq \frac{2^N}{10} < 2^{53}$$

Since  $10 = 8 + 2 = 2^3 + 2^1$  then  $2^3 < 10 < 2^4$  We can change the bounds of our inequality above.

$$\frac{2^N}{16} = \frac{2^N}{2^4} < \frac{2^N}{10} < \frac{2^N}{2^3} = \frac{2^N}{8}$$

and then we can re-write the middle comparison like this:

$$2^{N-4} < \frac{2^N}{10} < 2^{N-3}$$

so if we want:

$$2^{52} \leq \frac{2^N}{10} < 2^{53}$$

then best  $N$  is 56, because that will make the upper inequality the same as the lower one.

We can also check that this does what we want.

```
2**52 <= 2**56 //10 < 2**53
```

True

Now we can get the number we will use for  $J$ . So far, mathematically, we would have:

$$J \approx \frac{2^{56}}{10}$$

but we need to find an integer value, so we divide and separate the `q` uotient and `r` emainder.

```
q, r = divmod(2**56, 10)
```

Next we check the remainder to decide if we should round up by 1 or not.

```
r
```

```
6
```

$6 > 5 = \frac{10}{2}$  so we round up. Since the remainder is more than half of the divisor it is closer to the next number up, so we increment.

```
J = q+1  
J
```

```
7205759403792794
```

then we can check the length in bits of that number

Python can print it for us:

```
bin(J)
```

```
'0b11001100110011001100110011001100110011001100110011001100110011010'
```

then we note that the first 2 characters are not a part of the binary representation, but an indicator that it *is* a binary string, so we subtract 2

```
len(bin(J))-2
```

```
53
```

Which is 53 as expected! To get the actual number we represent in the fraction part we want to drop the left most bit.

To actually represent our final number, we want to drop the left most bit. Remember, we found the number that gets represented including the additional 1 outside of the sum of the bits in the fraction.

```
significand = J-2**52  
significand
```

```
2702159776422298
```

or in binary:

```
bin(significand)
```

```
'0b1001100110011001100110011001100110011001100110011001100110011010'
```

Now, we go back to the  $e$ . We need  $52 - e + 1023 = 56$  so we solve to find  $e = 52 + 1023 - 56$

```
e = 52-56+1023  
e
```

```
1019
```

So our representation of .1 would be:

```
exp_bin = bin(e)[2:]  
sig_bin = bin(significand)[2:]  
'0' + exp_bin + sig_bin
```

dropping the first two

see on float exposed

```
float hex( 1)
```

If we take the binary above, it matched this for the part before the p. `0b1 1001 1001 1001 1001 1001 1001 1001 1001 1001 1001 1001`  
`1001 1001 1001 1010`

after the p is the exponent of  $-4 = 1019 - 1023$ . Which matches the approximation we found.

We can also check like this:

( J ) / 2 \*\* 56 == .1

this confirms that the approximation we found is the same as the float representation of .1.

## 21.6. Prepare for Next Class

none

## 21.7. Review today's class

1. Write a C program to compare values as doubles and as float (single precision/32bit) to see that this comparison issue is related to the IEEE standard and is not language specific. Make notes and comparison around its behavior and include the program in a code cell in cdouble.md

## 21.8. More Practice

1. Write a C program to compare values as doubles and as float (single precision/32bit) to see that this comparison issue is related to the IEEE standard and is not language specific. Make notes and comparison around its behavior and include the program in a code cell in cdouble.md
  2. In floatexpt.md design an experiment using the `fractions.Fraction` class in Python that shows helps illustrate why `.1*3 == .3` evaluates to `False` but `.1*4 == .4` evaluates to `True`. Your file must include both code and interpretation of the results.

## 21.9. Experience Report Evidence

## 21.10. Questions After Today's Class

### 21.10.1. Why can't systems just interpret decimal numbers like humans can?

Because it has to be represented mechanically or electrically for it to be a machine.

### 21.10.2. My question is how bad can the approximations get when calculating floats? How much precision gets lost when dealing with fractional numbers?

The quality of the approximation varies depending on the particular number.

At the bottom of [float exposed](#) you can see how close the next value is.

For 1 (the link above) the next number is a little more than 2.22e-16 away.

For 1532.625 the next value is 1.22e-4 away.

For 4503599627370497.0 to 9007199254740991.0 the next value is 1.0 away, that is we can only represent integers between those two values, nothing in between.

### 21.10.3. Did the people that came from an academia background typically design and implement these low-level systems or people in industry?

A lot of this work was deep collaborations between academia and industry. Some of it occurred in universities, some of it was at places like Bell Laboratory. That was a research institute inside of the for profit Bell Telephone Company.

### 21.10.4. How can I practice what we learned today for better understanding?

This is a hard topic and it will come back up in CSC411.

Also, I recommend reading these notes carefully, and trying the [float.exposed](#) site.

### 21.10.5. Does this process of going through all the bits increase in time with more bytes? Or is there a set number of bits?

This standard is a fixed size of 64 bits, but there are others with different numbers of bits.

### 21.10.6. How different was the initial standard from the one that exists today?

The initial standard defined fewer basic formats, more were introduced in 2008. Official IEEE standards are not free so they're slightly harder to read easily.

We do not actually get a .1 for doing math. It is close, but not exact. Unless your programming environment has a different base type.

## 22. What is a computer?

- how, physically, do we get the components we have seen?
- what other components do we need?
- how are those implemented

How have computers changed over time?

- at the physical level
- what was the context and motivation for these advances?
- how does that context influence how we use computers today?
- how does that influence computing as a discipline?

### 22.1. Let's start with a dictionary

we can start with a dictionary

- note that this starts with reference to a person.

#### 22.1.1. Computers as people

- Use of the word computer to refer to the person still common how recently 1950s
- the movie [hidden figures](#) is available on Disney+ with subscription or other streaming platforms for ~\$4 streaming rental.
- the book [hidden figures](#) is available at URI's library

#### 22.1.2. Computers as Machines

Computers as machines started later. We started with mechanical, analog and then moved to electronic and then digital.

#### 22.1.3. How much do we talk about computers?

[how much do we talk about them changes over time](#)

## 22.2. Mechanical Calculators

how do we actually like physically make it be machine

well we've we've talked we handed out that like it's going to reduce down to or isn't my check and logical operations write those de back much further than

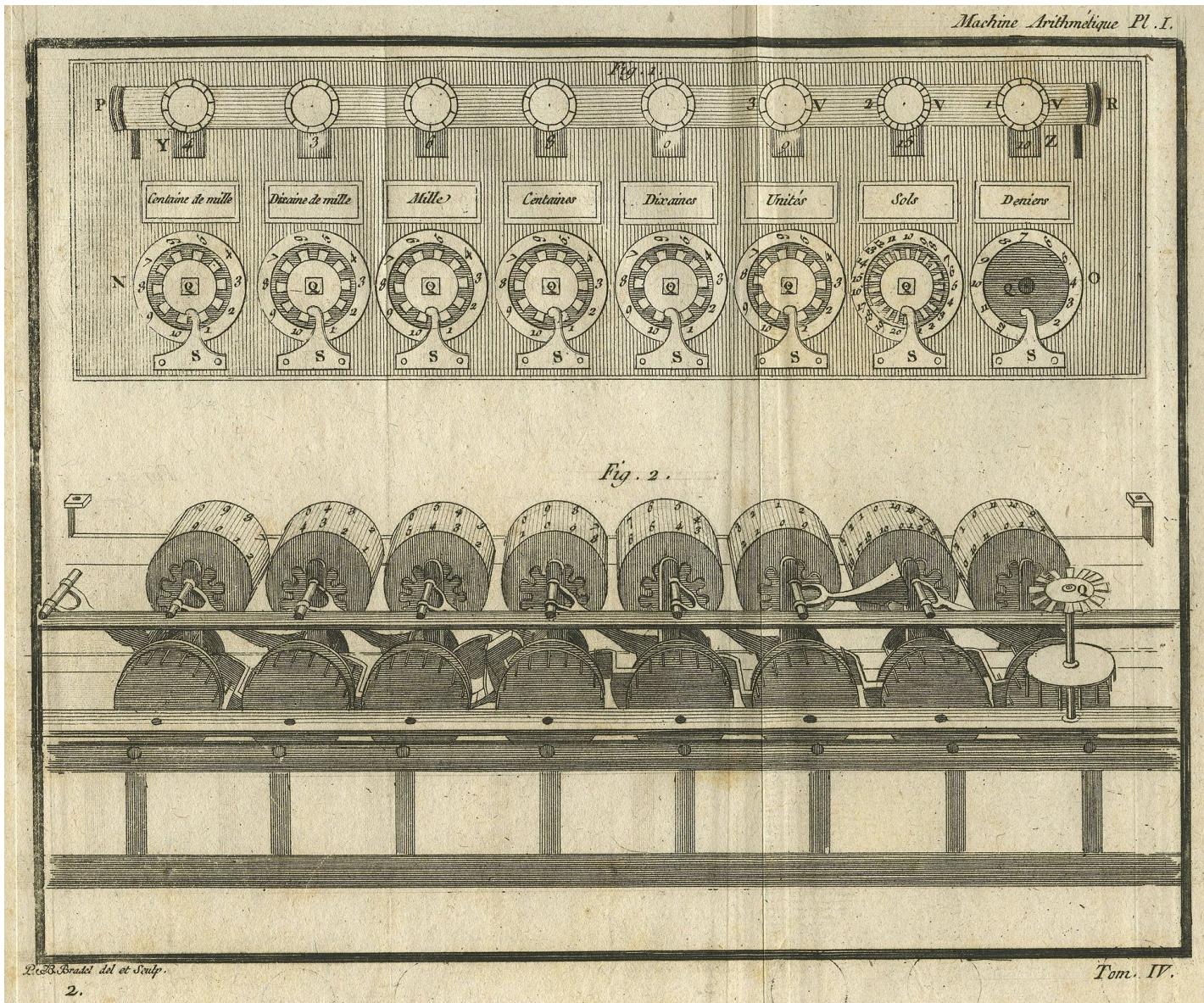


what is the mechanical calculator it works by like incrementing rather than through the logic we worked out for a digital logic based adder.

### Why did he make this?

He was 18 and his father was a tax commissioner in France and he wanted to like reduce his father's workload

so he invented this calulator machine and received roayl privilege from France in 1649 to be only person allowed to build a manufactured Computing a calculator is like mechanical calculators



Contrast this royal privilege with the 1970s where in resolving some other conflict, a court that declared the content of the computer that they cannot be found it at all and it's free for anyone to use the concept of a computer

## 22.3. How did this change over time?

calculators that are still analog so they're still working with mechanical systems using Waze electricity becomes easier

[timeline of computing](#)

### 22.3.1. Model K Adder (1937)

- George Stibitz took some pieces at home from work at Bell Laboratory and got it working on his kitchen table.
- it can do four bit addition
- uses a telephone relay switch or an electromechanical switch so they're using like a

Relays are designed to repeat or relay a signal to the next circuit to complete long distance telegraphs and early telephone. As the

[Skip to main content](#)

magnitude of it for the next length of the journey.

precursor to the complex number calculator he demonstrated how this works in combination with Telegraph for the first remote access

- complex number calculator was at Bell Labs in New York City at the time in 1940 at a Conference at Dartmouth in Hanover New Hampshire and he used a telegraph to do remote calculations on this calculator and bring them back

### 22.3.2. Intel 4004 (1971)

- First commercially produced microprocessor
- 2,250 transistors
- Could perform up to 90,000 operations per second in four bit chunks
- 740 kHz clock speed

### 22.3.3. So how do these things actually work

- We can build an adder mechanically with marbles and wood

As electricity became more available, they realized that in terms of mathematical operations, electrical components resemble springs and switches

- first vacuum tubes: or diodes
- diodes prevent flow of electricity in one direction and allow in the other. They can be used to create circuits that behave like the logical operations, and create the gates.
- diodes only are easy for  and  gates,
- transistors can operate as a switch or amplifier and can also be used to build logic gates
- they're faster, smaller, and better at more types of gates than diodes

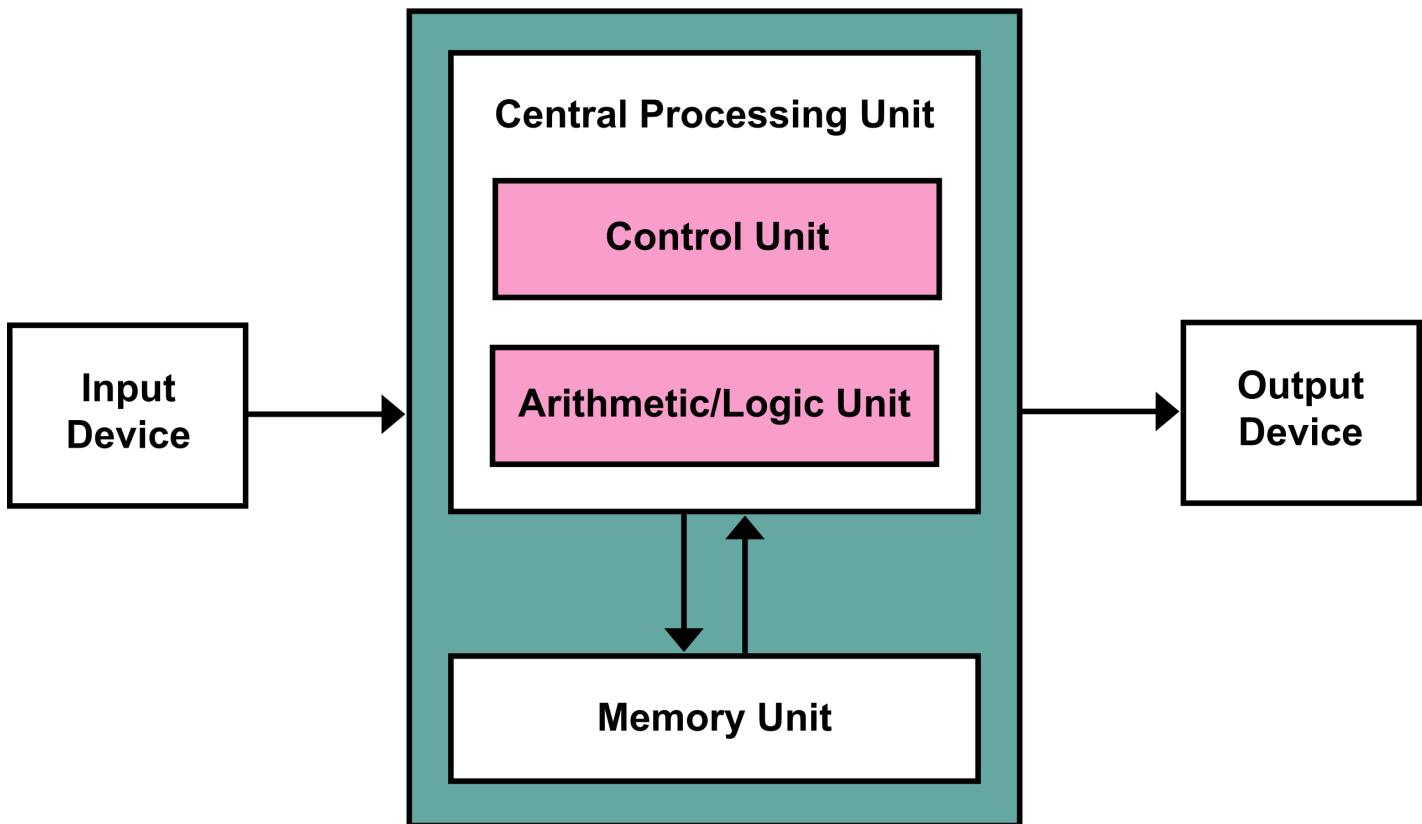
## 22.4. Early Computers

During this time small, lots of small computers were made, but each was made completely by its creators, there was no standards, per say.

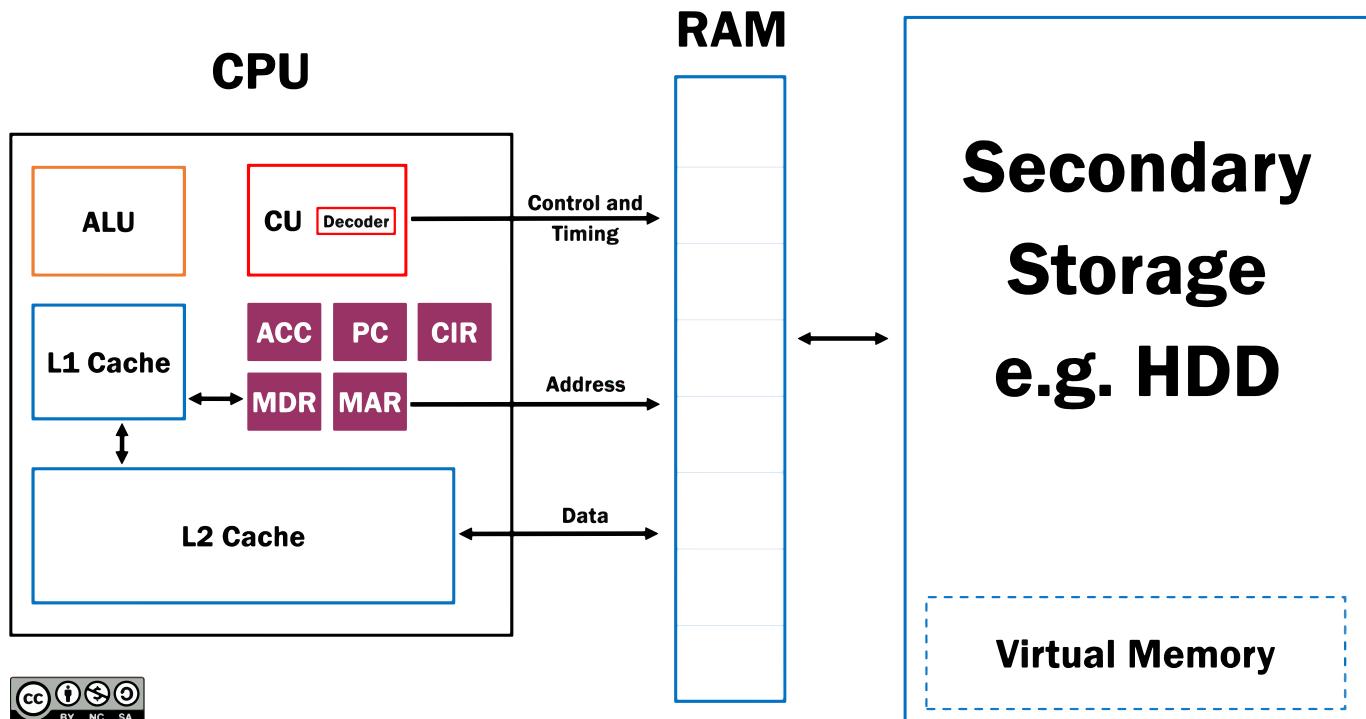
These computers were also stored program computers. Meaning their operation at a program level was fixed by the circuitry.

switch the circuit to do different things between the numbers so this would get us bitwise operations of an indoor and outdoor on our numbers

## 22.5. von Neumann Architecture



## Computer Systems - Von Neumann Architecture



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we eventually need clocks to time things and synchronize things to like know when to clear and when to change so that you if you want to do multiple things in sequence you can do that what else you need or want to do multiple things in sequence but don't know what else we need a general now

In 1945 we get a draft of a general template. This is basically what we use today.

## 22.6. Apollo Guidance Computer (AGC)

The AGC was the onboard computer for NASA's Apollo programs. It provided navigation for the control capsule as well as controlled the spacecraft during moon landings. The AGC had only 72KB of fixed memory (589,824 bits). Unlike many early computers, the software for the AGC was stored in its memory and was not physically built into its hardware's circuitry.

Additionally, this computer had RAM, which was memory that could be changed by the computer while it was running. This memory had a capacity of only 4KB (32,768 bits), which was still enough to store all the data needed to perform all calculations necessary for the missions. The AGC could be controlled by the astronauts in the command capsule by sending commands via a numeric keyboard. Its user interface consisted of a simple screen and a set of status lights that relayed information to the astronauts.

This computer is very similar to how modern computers work in the sense that it can keep data in its fixed memory even while the computer is off.

To learn more about the AGC and how it worked, you can view [this article](#), or view the [official NASA public docs](#) on it.

## 22.7. Storage

- there are some things we have not yet seen in detail in that diagram
- Ram Is Random Access we can access it whenever we want we can read and write to
- ROM: is read only memory; the instructions are Permanently

In the stored program computers, the programs were in ROM.

The very earliest computers could not store any values without power.

- Register: data currently processing
- Memory: will be required for processing
- Disk: long term storage

## 22.8. Questions After Class

### 22.8.1. Why did we stray away from simplicity of early computers?

Computers got more complex in their architecture so that they can complete more complex calculations and run more complex problems.

### 22.8.2. My question is if we are in a plateau now or if it is possible to go through

We're out of the range where Moore's law applies. Quantum computing is on the horizon, but it breaks the abstractions. It switches from bits being the basis to cubits, which are stochastic as the basis.

### 22.8.3. What are the PC, MAR, MDR, etc. and what do they do

They are various registers that each have a specific role. Learning all of these in more detail is a good Explore badge or a single one is in more practice.

### 22.8.4. how does a motherboard work with all of these

A motherboard contains all most of those components. This is also a good Deeper exploration.

### 22.8.5. How can I learn more about the basics of Computers?

The computer history museum links above are a good place to start.

This is a good explore badge topic.

### 22.8.6. What are some examples of von Neumann Architectures?

This is the design that our computers all use.

### 22.8.7. Is Gigahertz a measure of electricity or computing speed?

It is a measurement of frequency which is the inverse of time. If something happens at a frequency of 1Hz, it occurs once per second. 10Hz is 10 times per second.

In the processor it is the speed of the clock signal; a factor in how many calculations the computer can do per second.

### 22.8.8. At what point were most, if not all, human computers phased out?

Some point in the late 70s or 80s I think. NASA employed people in this role through 70s.

More research on this detail is a good community badge option.

### 22.8.9. If we tried to add a GPU to Von Neumann's architecture, would it just be its own thing or there would be a way to fit it in the diagram?

It is outside of the CPU, but it is also newer as a separate component, so it is separate.

### 22.8.10. What other types of architecture were there?

The main competing architecture was the Harvard architecture. This is a good explore badge topic.

## 22.8.11. When defining a computer, is it best to define the most current model of a computer? Or how everything functions bare bones?

What definition dependsd on the context. If you are talking to a child who is trying to learn basic typing they need to know different things than a teenager trying to choose what type of comptuer to bring to college, which is different than the model you need to keep in mind when you're working in a high level language, which is different than what you need when you are writing drivers.

## 22.8.12. How do Quantum computer logic gates differ from what we use now exactly

Quantum computers operate on a fundamentally different object, instead of bits they have [qubits](#). There represent, essetially some uncertainty, or randomness in the behavior, so then there are different operations needed.

URI has a [MS](#) in Quantum Computing in the Physics Dept

## 22.8.13. Intel 4004 (1971) -> How it worked by Tyler Hanlon

This was the first general purpose programmable processor which people could buy and then make or buy their own software to customize it with. This was a breakthorugh in computing as it allowed consumers to have a say in what software was used in their electronics without having to make their own. This was extremely influential advancmenet inearly comuting technologies becuase it made multiple softwares more accessible and deliverable to a wider audience. It is one of the smallest microprocessors ever made, and was develope for use in a Japanese calculator company, but was powerful enought o actually be used for a wide variety of functions.

Sources: [https://www.intel.com/content/www/us/en/history/museum-story-of-intel-4004.html#:~:text=That's when the Intel®,wide](https://www.intel.com/content/www/us/en/history/museum-story-of-intel-4004.html#:~:text=That's%20when%20the%20Intel%20wide)  
variety of electronic devices.

<https://spectrum.ieee.org/chip-hall-of-fame-intel-4004-microprocessor>

## 22.9. Prepare for Next Class

Spend a few minutes thinking about what you know about memory and reading and writing files in programming. Make some notes about it (that you do not need to submit). (you'll discuss this with classmates at the start of class)

## 22.10. Review today's class

1. Pick a component that is in the more detailed von Neumann (other than the ALU) and contribute an explanation of what it is to your group repo. Coordinate with your team so that each contribution is a different component by creating an issue stating what you will work on before contributing. Link to your PR in the group repo in your badge PR. All contributions should include a description of the component- what it does and how it is built- and it's predecessors. All must include sources as markdown links.
2. review a classmate's PR providing feedback and either approving or requesting changes
3. Work with your group mates to ensure both your PR and the one you reviewed get approved and merged.

## 22.11. More Practice

1. Pick a component that is in the more detailed von Neumann (other than the ALU) and contribute an explanation of what it is to your group repo. Coordinate with your team so that each contribution is a different component by creating an issue stating what you will work on before contributing. Link to your PR in the group repo in your badge PR. All contributions should include a description of the component- what it does and how it is built- and its predecessors. All must include sources as markdown links.
2. review a classmate's PR providing feedback and either approving or requesting changes
3. Work with your group mates to ensure both your PR and the one you reviewed get approved and merged.
4. Read about [systems abstractions](#) in CACM and answer reflection questions below in systemsabstractions.md based on the systems abstraction reading:

1. What are your overall thoughts on this article? (include how much is new vs familiar, easy vs hard to understand)
2. How has your understanding of these changed during this course?
3. Do you think you understand this article more now than you would have at the beginning of the semester?
4. Write 3 questions and their answers that could be a quiz to see if someone understood or had misconceptions.

## 22.12. Experience Report Evidence

### 22.13. Questions After Today's Class

## 23. How do different types of storage work together?

How do you think about memory?

What was shared in common with your classmates?

What was different?

### 23.1. Why do we need to know about this?

- computers are not magic and edge cases help you see that
- in case you want to do high performance programming
- it's good practice with abstraction

### 23.2. Hardware vs Software abstraction

Abstraction is to remove details and use higher level units

in hardware our abstractions are less leaky because it is less forgiving.

software abstractions can suffer from leaks; think git- it's hard to learn because the abstraction is leaky.

a lot of programming is *designing* abstractions, to get good at making something, you study examples first- good and bad- to learn what to do, and not to do.

- the above is a blog post by one of the co-founders and the 2010-2019 CEO of Stack Overflow Joel Spolsky

### 23.3. How to store a value

We need a few more components:

- **mux** select one of two values
- **flip-flop** hold a value until told otherwise

**register**

this gives us SRAM which can hold a value as long as the system has power (1963)

### 23.4. another way to physically store a value

DRAM uses one transistor and one capacitor. (SRAM uses 4-6 transistors)

a capacitor holds a charge for a time, but gradually fades, so it has to be refreshed

ROM is a diode matrix traditionally

- hardware encodes the instructions
- cannot be changed without rewiring

PROM

- can be reprogrammed once after device is made
- used for firmware/microcode

EPROM or EEPROM

- treated like ROM
- can be erased & reprogrammed
- but not infinitely, very limited number of times
- holds value when power goes away, UV light or electricity can re-program
- 

SRAM:

- is volatile; it needs power to hold a value
- is fast
- takes up more space on the chip (uses 4-6 transistors per bit)
- typically used of cache and internal registers

DRAM:

- is volatile; it needs power to hold a value
- is slower and requires a refresh

- used for the main RAM

Flash memory

- non-volatile; holds a value without power, can be electrically erased and re-programmed
- comprised of memory “cells” in layered boards
- memory cells are mosfets - a different type of transistor that retains a state after power is removed and put back
- implemented with EEPROM
- designed for large blocks and limited writes (~10k)
- used for SSD, USB flash drives, smartphones, etc
- slow to write, fast to read

## 23.5. Prepare for Next Class

None.

## 23.6. Review today's class

*this is integrative-2*

1. Add `conclusion.md` to your KWL repo. In the file include 2 sections: summary with an overall description of what you learned and how this course was/not helpful to you (paragraph or bullet form is fine) key points with the top 10 things you want to make sure you remember from this class
2. Reflect on how this course impacts programming/debugging skills in `skillup.md`. You can write this as how you think your own skill has improved **or** as if you are convincing another student to take this class. Touch on at least three topics.

## 23.7. More Practice

*this is integrative-2*

1. Create `in_five_years.md` and answer the following two questions: What do you think you will remember from this class in five years? What parts of this course's content do you think will change the most in five years?
2. Reflect on how this course impacts programming/debugging skills in `skillup.md`. You can write this as how you think your own skill has improved **or** as if you are convincing another student to take this class. Touch on at least three topics.
3. Submit a PR with either [advice to future students on how to succeed in the course](#) or [on why a student should take this course](#). Each of those is linked to where you should add your advice.

## 23.8. Experience Report Evidence

## 23.9. Questions After Today's Class

### 23.9.1. What kind of tools did you use for a software defined radio?

### **23.9.2. Will RAID ever be 100% fail proof?**

RAID configurations can be data failure proof as long as not too many drives die at the same time and that they are all replaced as soon as they fail.

### **23.9.3. Is the clock speed of a computer how fast the clock goes on and off? and is there ever an error that occurs if the clock speed goes too slow?**

It is the frequency of the clock signal we will learn more about next week.

### **23.9.4. Do you think this area in computer science/software engineering is harder than other fields like data science or web development?**

I think they're just different. Working with hardware is certainly a different pace.

### **23.9.5. Can these different types of ram not be included or are they in every computer?**

most modern computers have cache, RAM, ROM, and solid state storage. these are implemented with different types of physical memory.

### **23.9.6. If a computer has extensive resources would it be more efficient to never use DRAM and only use SRAM?**

This might be possible, but I am not sure.

### **23.9.7. What is EEPROM?**

Electrically Erasable Programmable Read Only memory

### **23.9.8. How does knowing the hardware/internal components of the computer help improve one's understanding of what they're trying to achieve as a developer for something like a program?**

It helps you think through how abstractions work and understanding what actually happens will help you design more efficient code.

### **23.9.9. How much would it cost to fix a cable that a whale found itself tangled in?**

the cable is mostly buried. It gets damaged mostly by anchors of ships.

### **23.9.10. Is ROM still used in modern computers?**

Only for the very beginning of the boot sequence, but yes.

That is a good question, but I do not have a precise answer.

### 23.9.12. When they go down to set the transatlantic cable how long does it take to get them back up?

I do not know this and a quick search did not yeild results. Finding this is worth a community badge (could be expanded to an explore).

## KWL Chart

### Working with your KWL Repo

#### ! Important

The `main` branch should only contain material that has been reviewed and approved by the instructors.

1. Work on a specific branch for each activity you work on
2. when it is ready for review, create a PR from the item-specific branch to `main`.
3. when it is approved, merge into main.

#### Tip

You c  
on yo

### Minimum Rows

```
# KWL Chart

<!-- replace the _ in the table or add new rows as needed -->

| Topic | Know | Want to Know | Learned |
| -----| ----- | ----- | ----- |
| Git | _ | _ | _ |
| GitHub | _ | _ | _ |
| Terminal | _ | _ | _ |
| IDE | _ | _ | _ |
| text editors | _ | _ | _ |
| file system | _ | _ | _ |
| bash | _ | _ | _ |
| abstraction | _ | _ | _ |
| programming languages | _ | _ | _ |
| git workflows | _ | _ | _ |
| git branches | _ | _ | _ |
| bash redirects | _ | _ | _ |
| number systems | _ | _ | _ |
| merge conflicts | _ | _ | _ |
| documentation | _ | _ | _ |
| templating | _ | _ | _ |
| bash scripting | _ | _ | _ |
| developer tools | _ | _ | _ |
| networking | _ | _ | _ |
| ssh | _ | _ | _ |
| ssh keys | _ | _ | _ |
| compiling | _ | _ | _ |
| linking | _ | _ | _ |
| building | _ | _ | _ |
| machine representation | _ | _ | _ |
```

[Skip to main content](#)

logic gates		_		_		_	
ALU		_		_		_	
binary operations		_		_		_	
memory		_		_		_	
cache		_		_		_	
register		_		_		_	
clock		_		_		_	
Concurrency		_		_		_	

## Required Files

This lists the files for reference, but mostly you can keep track by badge issue checklists.

## Team Repo

### Contributions

Your team repo is a place to build up a glossary of key terms and a “cookbook” of “recipes” of common things you might want to do on the shell, bash commands, git commands and others.

For the glossary, follow the [jupyterbook](#) syntax.

For the cookbook, use standard markdown.

to denote code inline [use single backticks](#)

to denote code inline `use single backticks`

to make a code block use 3 back ticks

```  
to make a code block use 3 back ticks  
```

To nest blocks use increasing numbers of back ticks.

To make a link, [\[show the text in squarebrackets\]\(url/in/parenthesis\)](#)

## Collaboration

You will be in a “team” that is your built in collaboration group to practice using Git Collaboratively.

There will be assignments that are to be completed in that repo as well. These activities will be marked accordingly. You will take turns and each of you is required to do the initialization step on a recurring basis.

This is also where you can ask questions and draft definitions to things.

## Peer Review

[Skip to main content](#)

If there are minor errors/typos, suggest corrections inline.

In your summary comments answer the following:

- Is the contribution clear and concise? Identify any aspect of the writing that tripped you up as a reader.
- Are the statements in the contribution verifiable (either testable or cited source)? If so, how do you know they are correct?
- Does the contribution offer complete information? That is, does it rely on specific outside knowledge or could another CS student not taking our class understand it?
- Identify one strength in the contribution, and identify one aspect that could be strengthened further.

Choose an action:

- If the suggestions necessary before merging, select **request changes**.
- If it is good enough to merge, mark it **approved** and open a new issue for the broader suggestions.
- If you are unsure, post as a **comment** and invite other group members to join the discussion.

## Review Badges

### Review After Class

After each class, you will need to review the day's material. This includes reviewing prismia chat to see any questions you got wrong and reading the notes. Most days there will be specific additional activities and questions to answer. These should be in your KWL repo. Review activities will help you to reinforce what we do in class and guide you to practice with the most essential skills of this class.

### 2023-09-07

[related notes](#)

Activities:

1. Review the notes after I post them.
2. Fill in the first two columns of your KWL chart (on a branch for this badge).
3. [review git and github vocabulary](#) (include link in your badge PR)
4. Post an introduction to your classmates [on our discussion forum](#)

### 2023-09-12

[related notes](#)

Activities:

1. [review notes after they are posted](#), both rendered and the raw markdown include links to each in your badge PR
2. map out your computing knowledge and add it to your kwl chart repo. this can be an image that you upload or a text-based outline in a file called prior-knowledge-map. (optional) try mapping out using [mermaid](#) syntax, we'll be using other tools that will

## 2023-09-14

related notes

Activities:

Any steps in a badge marked **lab** are steps that we are going to focus in on during lab time. Remember the goal of lab is to help you complete the work, not add additional work. The lab checkout will include some other tasks and then we will encourage you to work on this badge while we are there to help. Lab checkouts are checked only for completion though, not correctness, so steps of activities that we want you to really think about and revise if incorrect will be in a practice or review badge.

1. Read the notes. If you have any questions, post an issue on the course website repo.
2. Using your terminal, download your KWL repo. Include the command used in your badge PR.
3. Try using setting up git using your favorite IDE or GitHub Desktop. Make a file gitoffline.md and include some notes of how it went. Was it hard? easy? what did you figure out or get stuck on? Is the terminology consistent or does it use different terms?
4. **lab** Explore the difference between git add and git commit: try committing and pushing without adding, then add and push without committing. Describe what happens in each case in a file called gitcommit.md. Compare what happens based on what you can see on GitHub and what you can see with git status.

## 2023-09-19

related notes

Activities:

1. Create a merge conflict in your github in class repo and resolve it using your favorite IDE,. Describe how you created it, show the files, and describe how your IDE helps or does not help in ide\_merge\_conflict.md. Give advice for when you think someone should resolve a merge conflict manually vs using an IDE. (if you do not regularly use an, IDE, try VSCode)
2. Read more details about [git branches](#)(you can also use other resources) add [branches.md](#) to your KWL repo and describe how branches work, in your own words. Include one question you have about branches or one scenario you think they could help you with.

## 2023-09-21

related notes

Activities:

badge steps marked **lab** are steps that you will be encouraged to use lab time to work on.

1. Update your KWL chart with the new items and any learned items.
2. Clone the course website. Append the commands used and the contents of your [fall2023/.git/config](#) to a terminal\_review.md (hint: history outputs recent commands and redirects can work with any command, not only echo). Edit the README.md, commit, and try to push the changes. What happens and what GitHub concept that we have not used yet might fix it? see your [vocab-](#) repo for a list of key github concepts. (answer in the [terminal\\_review.md](#))
3. **lab** Organize the provided messy folder in a Codespace (details will be provided in lab time). Commit and push the changes. Answer the questions below in your kwl repo in a file called [terminal\\_organization.md](#)

[Skip to main content](#)

5. Find your team's repository. It will have a name like `fa23-team#` where `#` is a number 1-4. Join the discussion on that repo about naming your team. Link to your comment directly in your PR for this badge (use the 3 dots menu to get the comment specific URL).

`# Terminal File moving reflection`

1. How was this activity overall? Did this get easier toward the end?
2. When do you think that using the terminal will be better than using your GUI file explorer?
3. What questions/challenges/ reflections do you have after this exercise?

`## Commands used`

## 2023-09-26

related notes

Activities:

1. create an issue on your group repo for a tip or cheatsheet item you want to contribute. Make sure that your contribution does not overlap with one that amemb
2. clone your group repo.
3. work offline and add your contribution and then open a PR
4. review a class mate's PR.
5. Export your git log for your KWL main branch to a file called `gitlog.txt` and commit that as exported to the branch for this issue. **note that you will need to work between two branchse to make this happen.** Append a blank line, `## Commands`, and another blank line to the file, then the command history used for this exercise to the end of the file.

## 2023-09-28

related notes

Activities:

1. Review the notes, [jupyterbook docs](#), and experiment with the `jupyter-book` CLI to determine what files are required to make `jupyter-book build` run. Make your kwl repo into a jupyter book. Set it so that the `_build` directory is not under version control.
2. Add `docs.md` to your KWL repo and explain the most important things to know about documentation in your own words using other programming concepts you have learned so far. Include in a markdown (same as HTML `<!-- comment -->`) comment the list of CSC courses you have taken for context while we give you feedback.

## 2023-10-03

related notes

Activities:

1. Read about different workflows in git and describe which one you prefer to work with and why in favorite\_git\_workflow.md in your kwl repo. Two good places to read from are [Git Book](#) and the [atlassian Docs](#)

3. In commit\_contents.md, redirect the content of your most recent commit, its tree, and the contents of each tree and blob in that tree to the same file. Edit the file or use `echo` to put markdown headings between the different objects. Add a title `# Complete Commit` to the file and at the bottom of the file add `## Reflection` subheading with some notes on how, if at all this exercise helps you understand what a commit is.

## 2023-10-05

related notes

Activities:

1. Read today's notes when they are posted.
2. Add to your software.md a section about if that project does or does not adhere to the unix philosophy.
3. create methods.md and answer the following:

- which of the three methods for studying a system do you use most often when debugging?  
- do you think using a different strategy might help you debug faster sometimes? why or why not?

## 2023-10-12

related notes

Activities:

1. Make a table in gitplumbingreview.md in your KWL repo that relates the two types of git commands we have seen: plumbing and porcelain. The table should have two columns, one for each type of command. Each row should have one git plumbing command and at least one of the corresponding git porcelain command(s). Include two rows: `add` and `commit`.
2. Contribute to your group repo and review a classmate's contribution. Include a link to your contribution and review in your badge PR comment using markdown link syntax. Your contribution can be a short how to with a code excerpt or a resource. Include a link to your contribution and review in your badge PR comment using markdown link syntax:

[text to display](url/of/link)

## 2023-10-17

related notes

Activities:

1. find 2 more real world examples of using other number systems (either different bases or different symbols and bases) that are current. Describe them in `numbers.md`. Include links to your sources and be sure that the sources are trust worthy.
2. Calculate the maximum number of git objects that a repo can have without needing to use more than the minimum number of characters to refer to any object and include that number in gitcounts.md with a title `# Git counts`. Describe the scenario that would get you to that number of objects with the maximum or minimum number of commits in terms of what types of objects would exist. Assume normal git use with porcelain commands, not atypical cases with plumbing commands. *If you get stuck, outline what you know and then comment or message*

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## 2023-10-19

[related notes](#)

Activities:

1. Use git bisect to find the first bad commit in the [toy bug repo](#), save the command history and the bad commit hash to [git\\_debug.md](#)
2. Create [tagtypeexplore.md](#) with the template below. Determine how many of the tags in the course website are annotated vs lightweight using [git cat-file](#) to inspect the tags and the [git tag](#) help to determine which tags are of each type.

```
# Tags

<!-- short defintion/description in your own words of what a tag is and what it is for -->

## Inspecting tags

Course website tags by type:
- annotated:
- lightweight:
```

## 2023-10-24

[related notes](#)

Activities:

1. Update your KWL Chart learned column with what you've learned
2. Write a bash script that you can run in your group repo to generate a file with a list of all of your PRs and. Save the script as [groupcontributions.sh](#) and its output as [group\\_contributions-YYYY-MM-DD.md](#) in your KWL repo.

## 2023-10-31

[related notes](#)

Activities:

1. File permissions are represented numerically often in octal, by transforming the permissions for each level (owner, group, all) as binary into a number. Add [octal.md](#) to your KWL repo and answer the following. Try to think through it on your own, but you may look up the answers, as long as you link to (or ideally cite using jupyterbook citations) a high quality source.

1. Describe how to transform the permissions ``r--`, `rw-`, `rwx`` to octal, by treating each set as three digits.
  1. Transform the permission we changed our script to ``rwxr-xr-x`` to octal.
  1. Which of the following would prevent a file from being edited by other people 777 or 755 and why?

## 2023-11-02

[related notes](#)

1. create a new ssh key and configure it to your GitHub account
2. Practice using gcc. Repeat steps we did in class, change the order of parameters; try skipping steps to produce errors, etc.  
Then in `gcctips.md` summarize what you learned as a list of tips and reminders on what the parameters do/why/when you would need them (or not). (to reinforce what we learned)

## 2023-11-07

related notes

Activities:

3. Create some variations of the `hello.c` we made in class. Make `hello2.c` print twice with 2 print commands. Make `hello5.c` print 5 times with a for loop and `hello7.c` print 7 times with a for loop. Build them all on the command line and make sure they run correctly.
4. Write a bash script, `assembly.sh` to compile each program to assembly and print the number of lines in each file.
5. Put the output of your script in `hello_assembly_compare.md`. Add to the file some notes on how they are similar or different based on your own reading of them.

## 2023-11-14

related notes

Activities:

1. Run and examine how `rect.hack` and `max.hack` in the `nand2tetris/projects/05/` folder work. Make notes and answer the questions below in `assemblyexplore.md`.

1. Explain how `max.hack` works **in** detail.
2. Write code **in** a high level language that would **compile** into this program.
3. What does this `max.hack` assume has happened that it doesn't **include in its body**?

## 2023-11-16

related notes

Activities:

1. While we saw many types of gates today, but we actually could get all of the operations needed using only NAND gates. Work out how to use NAND gates to implement `and` and `or` in `nandandor.md`
2. Add `bitwise.md` to your kwl and write the bitwise operations required for the following transformations (replace the `(_)` with a bitwise operator (`&`, `|`, `^`, `>>`, `<<`)):

```
4 (_)_ 128  
12493 (_)_ -12494  
127 (_)_ 15  
7 (_)_ 56  
4 (_)_ -5  
45 (_)_ 37 = 37
```

[Skip to main content](#)

6  $(\_)$  8 = 0  
10  $(\_)$  5 = 15

## 2023-11-21

[related notes](#)

Activities:

1. Write a C program to compare values as doubles and as float (single precision/32bit) to see that this comparison issue is related to the IEEE standard and is not language specific. Make notes and comparison around its behavior and include the program in a code cell in cdouble.md

## 2023-11-28

[related notes](#)

Activities:

1. Pick a component that is in the more detailed von Neumann (other than the ALU) and contribute an explanation of what it is to your group repo. Coordinate with your team so that each contribution is a different component by creating an issue stating what you will work on before contributing. Link to your PR in the group repo in your badge PR. All contributions should include a description of the component- what it does and how it is built- and its predecessors. All must include sources as markdown links.
2. review a classmate's PR providing feedback and either approving or requesting changes
3. Work with your group mates to ensure both your PR and the one you reviewed get approved and merged.

## 2023-11-30

[related notes](#)

Activities:

*this is integrative-2*

1. Add `conclusion.md` to your KWL repo. In the file include 2 sections: summary with an overall description of what you learned and how this course was/not helpful to you (paragraph or bullet form is fine) key points with the top 10 things you want to make sure you remember from this class
2. Reflect on how this course impacts programming/debugging skills in `skillup.md`. You can write this as how you think your own skill has improved **or** as if you are convincing another student to take this class. Touch on at least three topics.

## Prepare for the next class

These tasks are not always based on things that we have already done. Sometimes they are to have you start thinking about the topic that we are *about* to cover. Getting whatever you know about the topic fresh in your mind in advance of class will help what we do in class stick for you when we start.

The correct answer is not as important for these activities as it is to do them before class. We will build on these in class. These are evaluated on completion only, but we may ask you questions or leave comments if appropriate, in that event you should reply and then we'll approve.

## 2023-09-12

Activities:

1. (for lab) Read the syllabus section of the course website carefully and explore the whole course [website](#)
2. Bring questions about the course to lab
3. (for class) Think about one thing you've learned really well (computing or not). Be prepared to discuss the following: How do you know that you know it? What was it like to first learn it?

## 2023-09-14

Activities:

1. Find the glossary page for the course website, link it below. Review the terms for the next class: shell, terminal, bash, git, GitHub.
2. Check your kwl repo before class and see if you have received feedback, reply or merge accordingly.
3. Make sure you have a working environment, see the list in the syllabus, including [gh](#) CLI if you use mac` . Use the discussions to ask for help.
4. Sign up for [announcements](#)

## 2023-09-19

Activities:

1. Reply below with any questions you have about using terminals so that you can bring it up in class
2. Be prepared to compare and contrast bash, shell, terminal, and git.
3. (optional) If you like to read about things before you do them, read about [merge conflicts](#). If you prefer to see them first, read this after.

## 2023-09-21

Activities:

1. Read the notes from 2023-09-19 carefully
2. Examine an open source project on GitHub. Answer the reflection questions below in [software.md](#) in your kwl repo on a branch that is linked to this issue. You do not need to make the PR, we will work with this in class on 2023-09-21.

### ## Software Reflection

1. Link and title of the project
1. What types of files are there that are not code?
1. What different types of code files are in the project? Do they serve different goals?

[Skip to main content](#)

1. Is there help for developers? users? which support is better?
1. What type of things are in the hidden files? who would need to see those files vs not?

Some open source projects if you do not have one in mind:

- pandas
- numpy
- GitHub CLI
- Rust language
- vs code
- Typescript
- Swift
- Jupyter book

## 2023-09-26

Activities:

1. Review your [software.md](#) file from last prepare
2. Review the notes from 2023-09-21
3. Bring git questions or scenarios you want to be able to solve to class on Thursday (in your mind or comment here if that helps you remember)
4. Update your `.github/workflows/experienceinclass.yml` file as to add another parameter to the last step ([Create Pull request](#)) `reviewers: <ta-gh-name>` where `<ta-gh-name>` is the github user name of the TA in your group. You can see your group on the organisation teams page named like "Fall 2023 Group X". Do this on a branch for this issue.

## 2023-09-28

Activities:

1. Read the 2023-09-26 notes when posted
2. Make sure that the `gh` CLI tool works by using it to create an issue called test on your kwl repo with `gh issue create`
3. Take a few minutes to think about a time you were debugging or pay attention the next time you debug something. Make note of how you think about the problem, how do you decide what to check? how do you decide what to try? what information do you look for?

## 2023-10-03

Activities:

1. Follow up on your grade plan PR and self reflection that you complete in lab

## 2023-10-05

1. Review the notes from past classes
2. Think through and make some notes about what you have learned about design so far. Try to answer the questions below in [design\\_before.md](#). If you do not now know how to answer any of the questions, write in what questions you have.

- What past experiences with making decisions about or studying design do you have?  
- What processes, decisions, and practices come to mind when you think about designing software?  
- From your experiences as a user you would describe the design of command line tools vs other GUI based too

## 2023-10-12

Activities:

**note this is posted on 2023-10-05 because October 10th is a “Monday” for URI classes**

1. Read the notes from October 5 and October 3. We will build on both of them on October 12. Make sure you have completed all of the steps in the github inclass repo from September too.
2. Start recording notes on *how* you use IDEs for the next couple of weeks using the template file below. We will come back to these notes in class later, but it is best to record over a time period instead of trying to remember at that time. Store your notes in your kwl repo in idethoughts.md on an [ide\\_prep](#) branch. **This is prep for much later, it does not go in the October 12 experience branch**

## 2023-10-17

Activities:

1. Read the notes from October 12. We will build on these directly in the future. **You need to have the [test](#) repo with the same status for lab on 10/13 and class on 10/17** Make sure you have completed all of the steps in the github inclass repo from September too.
2. Start recording notes on *how* you use IDEs for the next couple of weeks using the template file below. We will come back to these notes in class later, but it is best to record over a time period instead of trying to remember at that time. Record which IDE(s) you use, what tasks you do, what features you use, what extensions, etc. Store your notes in your kwl repo in idethoughts.md on an [ide\\_prep](#) branch. **This is prep for much later, it does not go in the October 17 experience badge branch**

## 2023-10-19

Activities:

1. Review [the course website releases](#) to get familiar with what content appears there
2. Review the GitHub Action files in your KWL repo and make note of what if any syntax in there is unfamiliar. (note that link may not work on the rendered website, but will work on issues)
3. Use quote reply or edit to see how I made a relative path to a location within the repo in this issue.
4. Use [git log](#) to view recent updates to the course website from the [October 12 class](#) to the [October 17 class](#) release
5. review the open PR about a build badge if you are intersted in that option and comment if anything is unclear or approve if it is helpful.

## 2023-10-24

Activities:

2. If you have not already or right before class, review the GitHub Action files in your KWL repo and make note of what if any syntax in there is unfamiliar. (note that link may not work on the rendered website, but will work on issues)
3. Use quote reply or edit to see how I made a relative path to a location within the repo in this issue.
4. Check out the [github action marketplace](#) to see other actions that are available and try to get a casual level of understanding of the types of things that people use actions for.

## 2023-10-26

Activities:

1. Read the 3 bulleted examples of [why use a cluster](#) from HPC carpentry.
2. Read [this discussion of why using a remote server](#)

## 2023-10-31

Activities:

1. Read about [connection protocols](#) in general and specifically https and ssh. Wikipedia is a good source to start from, and use additional sources to verify anything you find confusing. Be sure you have the basic terminology down and bring questions to class. Plan to check off your questions as they are answered during class on Tuesady and then submit others in your experience reflection.

## 2023-11-02

Activities:

No separate preparation, focus on badge work and reviewing the notes if you missed class.

Make sure you did the prep for 10-31, we will work from that on 11/2.

## 2023-11-02

[related notes](#)

Activities:

No separate preparation, focus on badge work and reviewing the notes if you missed class.

Make sure you did the prep for 10-31, we will work from that on 11/2.

## 2023-11-07

Activities:

1. Create operators.md and make some notes about what you know about operators. What kinds of operators are you familiar with? Which have you seen in programming? math?
2. Look over build/explore ideas if you plan to do any.
  - discussion repo
  - website repo
  - courseutils

## 2023-11-14

[related notes](#)

Activities:

Review the prep from 2023-11-07 or do it if you have not.

## 2023-11-16

[related notes](#)

Activities:

1. Refresh your knowledge of logical operations/ logic gates: and, or, xor, not. For an example reference see the logicemu emulator we will use in class

## 2023-11-21

[related notes](#)

Activities:

1. In fractionalbinary.md use 8 bits to represent the following numbers by using 4 bits as usual (8,2,4,1) and the other 4 bits are 1/2, 1/4, 1/8, 1/16th:
  - 3.75
  - 7.5
  - 11.625
  - 5.1875
1. Add to your file some notes about the limitations of representing non integer values this way. How much would using more bits help with, what limitations are not resolved by adding more bits. For example, how could you represent .1?

## 2023-11-28

[related notes](#)

[Skip to main content](#)

Activities:

none

## 2023-11-30

[related notes](#)

Activities:

Spend a few minutes thinking about what you know about memory and reading and writing files in programming. Make some notes about it (that you do not need to submit). (you'll discuss this with classmates at the start of class)

## More Practice Badges

### Note

these are listed by the date they were *posted*

More practice exercises are a chance to try new dimensions of the concepts that we cover in class.

### Note

Activities will appear here once the semester begins

## 2023-09-07

[related notes](#)

Activities:

1. Review the notes after I post them.
2. Fill in the first two columns of your KWL chart (on a branch for this badge).
3. review git and github vocabulary be sure to edit a file and make an issue or PR (include link in your badge PR)
4. Post an introduction to your classmates [on our discussion forum](#)

## 2023-09-12

[related notes](#)

Activities:

1. review notes after they are posted, both rendered and the raw markdown versions. Include links to both views in your badge PR comment.
2. read Chapter 1, "Decoding your confusion while coding" in [The Programmer's Brain](#) add a file called brain.md to your kwl repo

[Skip to main content](#)

program.

3. map out your computing knowledge and add it to your kwl chart repo in a file called prior-knowledge-map.md. Use mermaid syntax, to draw your map. GitHub can render it for you including while you work using the preview button.
4. Read more about [version control in general](#) and add a “version control” row to your KWL chart with all 3 columns filled in.

## 2023-09-14

### [related notes](#)

Activities:

Any steps in a badge marked **lab** are steps that we are going to focus in on during lab time. Remember the goal of lab is to help you complete the work, not add additional work. The lab checkout will include some other tasks and then we will encourage you to work on this badge while we are there to help. Lab checkouts are checked only for completion though, not correctness, so steps of activities that we want you to really think about and revise if incorrect will be in a practice or review badge.

1. Read the notes. If you have any questions, post an issue on the course website repo.
2. Using your terminal, download your KWL repo. Include the command used in your badge PR.
3. Try using setting up git using your favorite IDE or GitHub Desktop. Make a file gitoffline.md and include some notes of how it went. Was it hard? easy? what did you figure out or get stuck on? Is the terminology consistent or does it use different terms?
4. **lab** Explore the difference between git add and git commit: try committing and pushing without adding, then add and push without committing. Describe what happens in each case in a file called gitcommit\_tips.md. Compare what happens based on what you can see on GitHub and what you can see with git status. Write a scenario with examples of how a person might make mistakes with git add and commit and what to look for to get unstuck.

## 2023-09-19

### [related notes](#)

Activities:

1. Create a merge conflict in your github in class repo and resolve it using your favorite IDE, then create one and resolve it on GitHub in browser(this requires the merge conflict to occur on a PR). Describe how you created it, show the files, and describe how your IDE helps or does not help in ide\_merge\_conflict.md. Give advice for when you think someone should resolve a merge conflict in GitHub vs using an IDE. (if you do not regularly use an, IDE, try VSCode)
2. Learn about [GitHub forks](#) and more about [git branches](#)(you can also use other resources)
3. add [branches-forks.md](#) to your KWL repo and describe how branches work, what a fork is, and how they relate to one another. If you use other resources, include them in your file as markdown links.

## 2023-09-21

### [related notes](#)

Activities:

badge steps marked **lab** are steps that you will be encouraged to use lab time to work on.

2. Get set up so that you can pull from the introcompsyss/fall2023 repo and push to your own fork of the class website by cloning the main repo, then forking it and adding your fork as an additional `remote`. Append the commands used and the contents of your `fall2023/.git/config` to a terminalpractice.md (hint: `history` outputs recent commands and redirects can work with any command, not only echo). Based on what you know so far about forks and branches, what advantage does this setup provide? (answer in the `terminal_practice.md`)
3. **lab** Organize the provided messy folder (details will be provided in lab time). Commit and push the changes. Clone that repo locally.
4. For extra practice, re/organize a folder on your computer ( good candidate may be desktop or downloads folder), using only a terminal to make new directories, move files, check what's inside them, etc. Answer reflection questions in a new file, `terminal_organization_adv.md` in your kwl repo. Tip: Start with a file explorer open, but then try to close it, and use only command line tools to explore and make your choices. If you get stuck, look up additional commands to do accomplish your goals.
5. Find your team's repository. It will have a name like `fa23-team#` where `#` is a number 1-4. Join the discussion on that repo about naming your team. Link to your comment directly in your PR for this badge (use the 3 dots menu to get the comment specific URL).

```
# Terminal File moving reflection
1. How was this activity overall Did this get easier toward the end?
2. How was it different working on your own computer compared to the Codespace from?
3. Did you have to look up how to do anything we had not done in class?
4. When do you think that using the terminal will be better than using your GUI file explorer?
5. What questions/challenges/ reflections do you have after this?
6. Append all of the commands you used in lab below. (not from your local computer's history, from the codespace)
```

## 2023-09-26

related notes

Activities:

1. Find a resource/reference that helps explain a topic related to the course that you want to review. Make sure that your contribution does not overlap with one that another member is going to post by viewing other issues before you post your issue. Create an issue for your planned item.
2. Clone your group repo.
3. Work offline to add your contribution and then open a PR. Your reference review should help a classmate decide if that reference material will help them understand better or not. It should summarize the material and its strengths/weaknesses.
4. Complete a peer review of a class mate's PR. Use inline comments for any minor corrections, provide a summary, and either approve or request changes.
5. learn about options for `how git can display commit history`. Try out a few different options. Choose two, write them both to a file, `gitlog-compare.md`. Using a text editor, wrap each log with three backticks to make them "code blocks" and then add text to the file describing a use case where that format in particular would be helpful.

## 2023-09-28

related notes

Activities:

[Skip to main content](#)

1. Review the notes, [jupyterbook docs](#), and experiment with the `jupyter-book` CLI to determine what files are required to make `jupyter-book build` run. Make your kwl repo into a jupyter book. Set it so that the `_build` directory is not under version control.
2. Learn about the documentation ecosystem in another language that you know using at least one official source and additional sources as you find helpful. In `docs.md` include a summary of your findings and compare and contrast it to jupyter book/sphinx. Include a [bibtex based bibliography](#) of the sources you used. You can use [this generator](#) for informal sources and [google scholar](#) for formal sources.

## 2023-10-03

[related notes](#)

Activities:

1. Read about different workflows in git and add responses to the below in a workflows.md in your kwl repo. Two good places to read from are [Git Book](#) and the [atlassian Docs](#)
2. Update your kwl chart with what you have learned or new questions in the want to know column
3. Find the hash of the blob object that contains the content of your gitislike.md file and put that in the comment of your badge PR for this badge.

```
## Workflow Reflection
1. Why is it important that git can be used with different workflows?
1. Which workflow do you think you would like to work with best and why?
1. Describe a scenario that might make it better for the whole team to use a workflow other than the one you
```

## 2023-10-05

[related notes](#)

Activities:

1. Add to your software.md a section about if that project does or does not adhere to the unix philosophy and why. You can see what badge it was previously assigned in and the instructions on the [KWL file list](#).
2. create methods.md and answer the following:

```
- which of the three methods for studying a system do you use most often when debugging?
- which do you use when you are trying to understand something new?
- do you think the ones you use most often are consistently effective? why or why not? When do they work or
- what are you most interested in trying that might be different?
```

## 2023-10-12

[related notes](#)

Activities:

2. Read more details about [git internals](#) to review what we did in class in greater detail. Make a file `gitplumbingdetail.md` and

[Skip to main content](#)

- table or mermaid graph) that shows the relationship between at least three porcelain commands and their corresponding plumbing commands.
3. Create gitislike.md and explain main git operations we have seen (add, commit, push) in your own words in a way that will either help you remember or how you would explain it to someone else at a high level. This might be analogies or explanations using other programming concepts or concepts from a hobby.
  4. Contribute to your group repo and review a classmate's contribution. Include a link to your contribution and review in your badge PR comment using markdown link syntax. Your contribution can be a short how to with a code excerpt or a resource. (view the raw version of this issue page for the git internals link above for an example)

## 2023-10-17

related notes

Activities:

1. Read about the Learn more about the [SHA-1 collision attack](#)
2. Learn more about how git is working on changing from SHA-1 to SHA-256 and answer the transition questions below [gittransition.md](#)
3. find 2 more real world examples of using other number systems (either different bases or different symbols and bases) that are current. Describe them in [numbers.md](#)
4. Calculate the maximum number of git objects that a repo can have without needing to use more than the minimum number of characters to refer to any object and include that number in [gitcounts\\_scenarios.md](#) with a title [# Git counts](#). Describe 3 scenarios that would get you to that number of objects in terms of what types of objects would exist. For example, what is the maximum number of commits you could have without exceeding that number, how many files could you have? How could you get to that number of objects in the fewest number of commits? What might be a typical way to get there? Assume normal git use with porcelain commands, not atypical cases with plumbing commands. *If you get stuck, outline what you know and then request a review.*

## gittransition

```
## transition questions

1. Why make the switch?
2. What impact will the switch have on how git works?
3. Which developers will have the most work to do because of the switch?
```

## 2023-10-19

related notes

Activities:

1. Use your github-in-class repo to create a scenario where you can fix a problem using a git command from the [patching or debugging section of the docs](#). Create a log of what you did using the history or git log into a file [gitstory.md](#). If you have a project in another class or another badge in this class that causes you to use one in a real scenario, that can count. If not, for example, you could create a "bug" and then use bisect to find it.

2. Create tagtypes.md with the template below. Include an experiment that shows which if either type of tag creates a new git object. There are two types, try creating one of each a lightweight tag (provide only the tag name- what we did in class) and an annotated (provide a name and a message with `-m`). Determine many of the tags in the course website are annotated vs lightweight using what you learned about how tags are represented and `git cat-file` to see which is which.

```
# Tags
<!-- short defintion/description in your own words of what a tag is and what it is for -->

## Comparing tag types
<!-- include your experiment terminal history and interpretation -->
## Inspecting tags

Course website tags by type:
- annotated:
- lightweight:
```

## 2023-10-24

related notes

Activities:

1. Update your KWL Chart learned column with what you've learned
2. Write a bash script that you can run in your group repo to generate a file with a list of all of your PRs and PR reviews (you may go in and assign yourself to these PRs to make this easier). Save the script as groupcontributions.sh and its output as group\_contributions-YYYY-MM-DD.md in your KWL repo.

## 2023-10-31

related notes

Activities:

1. File permissions are represented numerically often in octal, by transforming the permissions for each level (owner, group, all) as binary into a number. Add octal.md to your KWL repo and answer the following. Try to think through it on your own, but you may look up the answers, as long as you link to (or ideally cite using jupyterbook citations) a high quality source.

```
1. Describe how to transform the permissions [`r--`, `rw-`, `rwx`] to octal, by treating each set as three digits.
1. Transform the permission we changed our script to `rwxr-xr-x` to octal.
1. Which of the following would prevent a file from being edited by other people 777 or 755 and why?
```

2. Answer the following in hpc.md of your KWL repo: (to think about how the design of the system we used in class impacts programming and connect it to other ideas taught in CS)

```
1. What kinds of things would your code need to do if you were going to run it on an HPC system?
1. What sbatch options seem the most helpful?
1. How might you go about setting the time limits for a script? How could you estimate how long a script
```

## 2023-11-02

related notes

Activities:

1. create a new ssh key and configure it to your GitHub account
2. Install gcc locally and practice using it. Repeat steps we did in class on your computer and then change the order of parameters; try skipping steps to produce errors, etc. Export the list of variations you tried and summarize what you learned as a list of tips and reminders on what the parameters do/why/when you would need them (or not) in gcctips.md. (to reinforce what we learned)
3. Write two short programs that do the same thing in different ways and compile them both to assembly (eg using a for vs while loop to sum numbers up to a number). Check the assembly to see if they produce the same thing or if it's different. Save your code (in code blocks) and notes about your findings in assemblycompare.md

## 2023-11-07

related notes

Activities:

On Seawulf, modify main.c from class to accept the integer as a command line argument instead of via input while running the program. See this tutorial for an example. 5. Write a bash script demo\_test.sh that runs your compiled program for each integer from 10 to 30 (syntax for a range is `{start..end}` so this would be `{10..30}`) 6. Write an sbatch script, batchrun.sh to run your script on a compute node and save the output to a file. The sbatch script should compile and link the program and then call the script. see the options 7. use scp to download your modified main, script files, and output to your local computer and include them in your kwl repo.

## 2023-11-14

related notes

Activities:

1. Run and examine how rect.hack and max.hack in the [nand2tetris/projects/05/](#) folder work. Make notes and answer the questions below in assemblyexplore.md.

1. What does rect.hack do?
2. What did you learn trying to figure out how it works?
3. Explain how max.hack works in detail.
4. Write code in a high level language that would compile into this program. Try writing multiple different \
5. What does this max.hack assume has happened that it doesn't include in its body?

## 2023-11-16

related notes

Activities:

[Skip to main content](#)

1. While we saw many types of gates today, but we actually could get all of the operations needed using only NAND gates. Work out how to use NAND gates to implement a half adder and describe it in nandhalf.md
2. In addertypes.md compare ripple adders and lookahead adders.

```

1. Give a synopsis of each adder type
1. Compare them in terms of time (assume that each gate requires one unit of time)
1. Compare them in terms of space/cost by counting the total number of gates required.

```

3. Add bitwise.md to your kwl and write the bitwise operations required for the following transformations (replace the `(_)` with a bitwise operator (`&, |, ^, >>, <<, ~`):

```

4 (_)
12493 (_)
127 (_)
7 (_)
4 (_)
45 (_)
45 (_)
3 (_)
6 (_)
10 (_)
128
-12494
15
56
-5
37 = 37
45 = 45
5 = 7
8 = 0
5 = 15

```

## 2023-11-21

related notes

Activities:

1. Write a C program to compare values as doubles and as float (single precision/32bit) to see that this comparison issue is related to the IEEE standard and is not language specific. Make notes and comparison around its behavior and include the program in a code cell in cdouble.md
2. In floatexpt.md design an experiment using the `fractions.Fraction` class in Python that shows helps illustrate why `.1*3 == .3` evaluates to `False` but `.1*4 == .4` evaluates to `True`. Your file must include both code and interpretation of the results.

## 2023-11-28

related notes

Activities:

1. Pick a component that is in the more detailed von Neumann (other than the ALU) and contribute an explanation of what it is to your group repo. Coordinate with your team so that each contribution is a different component by creating an issue stating what you will work on before contributing. Link to your PR in the group repo in your badge PR. All contributions should include a description of the component- what it does and how it is built- and its predecessors. All must include sources as markdown links.
2. review a classmate's PR providing feedback and either approving or requesting changes
3. Work with your group mates to ensure both your PR and the one you reviewed get approved and merged.
4. Read about [systems abstractions](#) in CACM and answer reflection questions below in systemsabstractions.md based on the

1. What are your overall thoughts on this article? (include how much is new vs familiar, easy vs hard to understand)
2. How has your understanding of these changed during this course?
3. Do you think you understand this article more now than you would have at the beginning of the semester?
4. Write 3 questions and their answers that could be a quiz to see if someone understood or had misconceptions.

## 2023-11-30

related notes

Activities:

*this is integrative-2*

1. Create [in\\_five\\_years.md](#) and answer the following two questions: What do you think you will remember from this class in five years? What parts of this course's content do you think will change the most in five years?
2. Reflect on how this course impacts programming/debugging skills in [skillup.md](#). You can write this as how you think your own skill has improved **or** as if you are convincing another student to take this class. Touch on at least three topics.
3. Submit a PR with either [advice to future students on how to succeed in the course](#) or [on why a student should take this course](#). Each of those is linked to where you should add your advice.

## KWL File List

## Explore Badges

### ⚠ Warning

Explore Badges are not required, but an option for higher grades. The logistics of this could be streamlined or the instructions may become more detailed during the penalty free zone.

Explore Badges can take different forms so the sections below outline some options. This page is not a cumulative list of requirements or an exhaustive list of options.

### 💡 Tip

You might get a lot of suggestions for improvement on your first one, but if you apply that advice to future ones, they will get approved faster.

## How do I propose?

Create an issue on your kwl repo, label it `explore`, and "assign" @brownsarahm.

In your issue, describe the question you want to answer or topic to explore and the format you want to use.

If you propose something too big, you might be advised to consider a build badge instead. If you propose something too small, you will get ideas as options for how to expand it and you pick which ones.

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## Where to put the work?

- If you extend a more practice exercise, you can add to the markdown file that the exercise instructs you to create.
- If its a question of your own, add a new file to your KWL repo.

### ! Important

Either way, there must be a separate issue for this work that is also linked to your PR

## What should the work look like?

It should look like a blog post, written tutorial, graphic novel, or visual aid with caption. It will likely contain some code excerpts the way the class notes do. Style-wise it can be casual, like how you may talk through a concept with a friend or a more formal, academic tone. What is important is that it clearly demonstrates that you understand the material.

The exact length can vary, but these must go beyond what we do in class in scope

## Explore Badge Ideas:

- Extend a more practice:
  - for a more practice that asks you to describe potential uses for a tool, try it out, find or write code excerpts and examine them
  - for a more practice that asks you to try something, try some other options and compare and contrast them. eg “try git in your favorite IDE” -> “try git in three different IDEs, compare and contrast, and make recommendations for novice developers”
- For a topic that left you still a little confused or their was one part that you wanted to know more about. Details your journey from confusion or shallow understanding to a full understanding. This file would include the sources that you used to gather a deeper understanding. eg:
  - Describe how cryptography evolved and what caused it to evolve (i.e. SHA-1 being decrypted)
  - Learn a lot more about a specific number system
  - compare another git host
  - try a different type of version control
- Create a visual aid/memory aid to help remember a topic. Draw inspiration from [Wizard Zines](#)
- Review a reference or resource for a topic
- write a code tour that orients a new contributor to a past project or an open source tool you like.

Examples from past students:

- Scripts/story boards for tiktoks that break down course topics
- Visual aid drawings to help remember key facts

For special formatting, use [jupyter book's documentation](#).

## Build Badges

[Skip to main content](#)

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# Proposal Template

If you have selected to do a project, please use the following template to propose a build

```
## < Project Title >

<!-- insert a 1 sentence summary -->

### Objectives

<!-- in this section describe the overall goals in terms of what you will learn and the problem you will solve -->

### Method

<!-- describe what you will do , will it be research, write & present? will there be something you build? what will you contribute -->

### Deliverables

<!-- list what your project will produce with target deadlines for each-->

### Milestones
```

The deliverables will depend on what your method is, which depend on your goals. It must be approved and the final submitted will have to meet what is approved. Some guidance:

- any code or text should be managed with git (can be GitHub or elsewhere)
- if you write any code it should have documentation
- if you do experiments the results should be summarized
- if you are researching something, a report should be 2-4 pages, plus unlimited references in the 2 column ACM format.

This guidance is generative, not limiting, it is to give ideas, but not restrict what you *can* do.

## Updates and work in Progress

These can be whatever form is appropriate to your specific project. Your proposal should indicate what form those will take.

## Summary Report

This summary report will be added to your kwl repo as a new file `build_report_title.md` where `title` is the (title or a shortened version) from the proposal.

This summary report have the following sections.

1. **Abstract** a one paragraph “abstract” type overview of what your project consists of. This should be written for a general audience, something that anyone who has taken up to 211 could understand. It should follow guidance of a scientific abstract.
2. **Reflection** a one paragraph reflection that summarizes challenges faced and what you learned doing your project
3. **Artifacts** links to other materials required for assessing the project. This can be a public facing web resource, a private repository, or a shared file on URI google Drive.

## Collaborative Build rules/procedures

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- Each student must submit a proposal PR for tracking purposes. The proposal may be shared text for most sections but the deliverables should indicate what each student will do (or be unique in each proposal).
- the proposal must indicate that it is a pair project, if iteration is required, I will put those comments on both repos but the students should discuss and reply/edit in collaboration
- the project must include code reviews as a part of the workflow links to the PRs on the project repo where the code reviews were completed should be included in the reflection
- each student must complete their own reflection. The abstract can be written together and shared, but the reflection must be unique.

## Build Ideas

### General ideas to write a proposal for

- make a [vs code extension](#) for this class or another URI CS course
- port the courseutils to rust. [crate clap](#) is like the python click package I used to develop the course utils
- build a polished documentation website for your CSC212 project with [sphinx](#) or another static site generator
- use version control, including releases on any open source side-project and add good contributor guidelines, README, etc

### Auto-approved proposals

For these build options, you can copy-paste the template below to create your proposal issue and assign it to [@brownssarahm](#).

For working alone there are two options, for working with a partner there is one.

#### 212 Project Solo- Docs focus

Use this option if your team for your 212 project is not currently enrolled in this class or does not want to do a collaborative build. This version focuses on the user docs.

```
## 212 Project Doc & Developer onboarding

Add documentation website and developer onboarding information to your CSC 212 project.

### Objectives

<!-- in this section describe the overall goals in terms of what you will learn and the problem you will solve

This project will provide information for a user to use the data structure implemented for a CSC 212 project

### Method

<!-- describe what you will do , will it be research, write & present? will there be something you build? what will you need to do to build it?
1. ensure there is API level documentation in the code files
1. build a documentation website using [jupyterbook/ sphinx/doxygen/] that includes setup instructions and examples
1. configure the repo to automatically build the documentation website each time the main branch is updated

### Deliverables

- link to repo with the contents listed in method in the reflection file
```

```
<!-- give a target timeline -->
```

## 212 Project Solo- Developer focus

Use this option if your team for your 212 project is not currently enrolled in this class or does not want to do a collaborative build. This version focuses on the contributor experience.

```
## 212 Project Doc & Developer onboarding

Add documentation website and developer onboarding information to your CSC 212 project.

### Objectives

<!-- in this section describe the overall goals in terms of what you will learn and the problem you will solve -->

This project will provide information for a user to use the data structure implemented for a CSC 212 project

### Method

<!-- describe what you will do , will it be research, write & present? will there be something you build? what will you contribute -->

1. ensure there is API level documentation in the code files
1. add a license, readme, and contributor file
1. add [code tours](https://marketplace.visualstudio.com/items?itemName=vscode-codetour) that help someone else learn
1. set up a PR template
1. set up 2 issue templates: 1 for feature request and 1 for bug reporting

### Deliverables

- link to repo with the contents listed in method in the reflection file

### Milestones

<!-- give a target timeline -->
```

## 212 Project Pair

Use this option if your teammate for your 212 project is in this class and wants to do a collaborative build.

```
## 212 Project Doc & Developer onboarding

Add documentation website and developer onboarding information to your CSC 212 project.

### Objectives

<!-- in this section describe the overall goals in terms of what you will learn and the problem you will solve -->

This project will provide information for a user to use the data structure implemented for a CSC 212 project

### Method

<!-- describe what you will do , will it be research, write & present? will there be something you build? what will you contribute -->

1. ensure there is API level documentation in the code files
1. build a documentation website using [jupyterbook/ sphinx/doxygen/] that includes setup instructions and examples
1. configure the repo to automatically build the documentation website each time the main branch is updated
1. add [code tours](https://marketplace.visualstudio.com/items?itemName=vscode-codetour) that help someone else learn
```

```
### Deliverables
```

```
- link to repo with the contents listed in method in the reflection file
```

```
### Milestones
```

```
<!-- give a target timeline -->
```

## Syllabus and Grading FAQ

### How much does activity x weigh in my grade?

There is no specific weight for any activities, because your grade is based on earning the badges. Everything at a level must be complete and correct.

### How do I keep track of my earned badges?

You will have several options. You will have a project board that you can track assigned work, in progress work and earned badges with in one place. This is quite different than checking your grade in BrightSpace, but using tools like this represents the real tools used by developers.

You will be able to use provided command line tools and github actions to produce a report of your status at any time from your PR list, starting in the third week. Additionally, at particular points in the course, an in class or class preparation activity will be for you to review a “progress report” that we help you create and update your success plan for the course.

### Also, when are each badge due, time wise?

Review and practice must start within a week, but I recommend starting before the next class. Must be a good faith completion within 2 weeks, but again recommend finishing sooner.

Experience reports for missing class is on a case by case basis depending on why you missed class. You must have a plan by the next class.

Explore and build, we'll agree to a deadline when you propose.

### Who should I request to review my work?

- Experience badge (inclass): TA in your group
- Experience report(makeup) `@brownsarahm``
- Review badge: `@instructors` team (it will convert to one of the three of us)
- Explore Proposal: `@brownsarahm`
- Explore Badge: `@brownsarahm`

- Build Badge: [@brownsarahm](#)

## Will everything done in the penalty free zone be approved even if there are mistakes?

No. In the penalty-free zone I still want you to learn things, but we will do extra work to make sure that you get credit for all of your effort even if you make mistakes in how to use GitHub. We will ask you to fix things that we have taught you to fix, but not things that we will not cover until later.

The goal is to make things more fair while you get used to GitHub. It's a nontrivial thing to learn, but getting used to it is worth it.

I want this class to be a safe place for you to try things, make mistakes and learn from them without penalty. A job is a much higher stakes place to learn a tool as hard as GitHub, so I want this to be lower stakes, even though I cannot promise it will be easy.

## Once we make revisions on a pull request, how do we notify you that we have done them?

You do not have to do anything, GitHub will automatically notify which ever one of us who reviewed it initially when you make changes.

## What should work for an explore badge look like and where do I put it?

It should be a tutorial or blog style piece of writing, likely with code excerpts or screenshots embedded in it.

[an example that uses mostly screenshots](#)

[an example of heavily annotated code](#)

They should be markdown files in your KWL repo. I recommend myst markdown.

## Git and GitHub

## I can't push to my repository, I get an error that updates were rejected

If your error looks like this...

```
! [rejected] main -> main (fetch first)
error: failed to push some refs to <repository name>
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

Your local version and github version are out of sync, you need to pull the changes from github to your local computer before you can push new changes there

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After you run

```
git pull
```

You'll probably have to resolve a merge conflict

## My command line says I cannot use a password

GitHub has strong rules about authentication. You need to use SSH with a public/private key; HTTPS with a Personal Access Token or use the [GitHub CLI auth](#)

## Help! I accidentally merged the Badge Pull Request before my assignment was graded

That's ok. You can fix it.

**note: these instructions use the main branch the way we use the badge branches and the feedback branch the way we use the main branch in this course**

You'll have to work offline and use GitHub in your browser together for this fix. The following instructions will work in terminal on Mac or Linux or in GitBash for Windows. (see [Programming Environment section on the tools page](#)).

First get the url to clone your repository (unless you already have it cloned then skip ahead): on the main page for your repository, click the green "Code" button, then copy the url that's shown

The screenshot shows a GitHub repository page for 'rhodyprog4ds / portfolio-brownsarahm'. The repository is private. At the top, there are navigation links: Code, Issues, Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings. A yellow banner at the top right says 'Compare & pull request'. Below the banner, there are buttons for 'main' (with a dropdown arrow), '5 branches', '1 tag', 'Go to file', 'Add file', and 'Code' (with a dropdown arrow). On the left, there's a list of files and their descriptions:

.github	correct path for jupytext conversion
about	mvoe notebook
template_files	convert notebooks to md
.gitignore	merge gh changes and ignore
README.md	Initial commit

To the right of the file list, there are three buttons: 'Clone with HTTPS' (with a 'Use SSH' link), 'Open with GitHub Desktop', and 'Download ZIP'.

Next open a terminal or GitBash and type the following.

[Skip to main content](#)

```
git clone
```

then past your url that you copied. It will look something like this, but the last part will be the current assignment repo and your username.

```
git clone https://github.com/rhodyprog4ds/portfolio-brownsarahm.git
```

When you merged the Feedback pull request you advanced the `feedback` branch, so we need to hard reset it back to before you did any work. To do this, first check it out, by navigating into the folder for your repository (created when you cloned above) and then checking it out, and making sure it's up to date with the `remote` (the copy on GitHub)

```
cd portfolio-brownsarahm  
git checkout feedback  
git pull
```

Now, you have to figure out what commit to revert to, so go back to GitHub in your browser, and switch to the feedback branch there. Click on where it says `main` on the top right next to the branch icon and choose feedback from the list.

The screenshot shows a GitHub repository page for 'rhodyprog4ds / portfolio-brownsarahm'. The 'Code' tab is selected. A yellow banner at the top left says 'feedback had recent pushes 1 minute ago'. On the right, there's a green 'Compare & pull request' button. Below the banner, there are buttons for 'main' (selected), '5 branches', '1 tag', 'Go to file', 'Add file', and 'Code'. A dropdown menu titled 'Switch branches/tags' shows 'main' (selected) and 'feedback' (highlighted). The main area displays a list of commits for the 'feedback' branch:

Commit	Date
a6f7f45 15 minutes ago	14 commits
correct path for jupytext conversion	17 hours ago
mvoe notebook	17 minutes ago
convert notebooks to md	17 hours ago
merge gh changes and ignore	3 days ago
Initial commit	3 days ago

Now view the list of all of the commits to this branch, by clicking on the clock icon with a number of commits

generated from [rhodyprog4ds/portfolio](#)

[Code](#) [Issues](#) [Pull requests](#) [Actions](#) [Projects](#) [Wiki](#) [Security](#) [Insights](#) [Settings](#)

[feedback](#) had recent pushes 15 minutes ago

[Compare & pull request](#)

[feedback](#) [5 branches](#) [1 tag](#)

[Go to file](#)

[Add file](#)

[Code](#)

This branch is 1 commit ahead of main.

[Pull request](#) [Compare](#)

<a href="#">brownsarahm</a> Merge pull request #1 from rhodyprog4ds/main ...	f301d90 16 minutes ago	15 commits
.github correct path for jupytext conversion	17 hours ago	
about move notebook	20 minutes ago	
template_files convert notebooks to md	17 hours ago	
<a href="#">View all changes</a>		

On the commits page scroll down and find the commit titled “Setting up GitHub Classroom Feedback” and copy its hash, by clicking on the clipboard icon next to the short version.

#### more examples

[brownsarahm](#) committed 3 days ago

[9427c13](#)

#### convert notebooks to md

[brownsarahm](#) committed 3 days ago

[e2f5b79](#)

#### Update jupytext\_ipynb\_md.yml

[brownsarahm](#) committed 3 days ago ✓

Verified

[7bd76c6](#)

#### solution

[brownsarahm](#) committed 3 days ago ✓

[fbe6613](#)

#### Setting up GitHub Classroom Feedback

[brownsarahm](#) committed 3 days ago ✕

[822cf5](#)

#### GitHub Classroom Feedback

[brownsarahm](#) committed 3 days ago ✕

[f3e0297](#)

#### Initial commit

[brownsarahm](#) committed 3 days ago ✓

[66c21c3](#)

[Newer](#) [Older](#)

Now, back on your terminal, type the following

[Skip to main content](#)

then paste the commit hash you copied, it will look something like the following, but your hash will be different.

```
git reset --hard 822cfe51a70d356d448bcaede5b15282838a5028
```

If it works, your terminal will say something like

```
HEAD is now at 822cfe5 Setting up GitHub Classroom Feedback
```

but the number on yours will be different.

Now your local copy of the `feedback` branch is reverted back as if you had not merged the pull request and what's left to do is to push those changes to GitHub. By default, GitHub won't let you push changes unless you have all of the changes that have been made on their side, so we have to tell Git to force GitHub to do this.

Since we're about to do something with forcing, we should first check that we're doing the right thing.

```
git status
```

and it should show something like

```
On branch feedback
Your branch is behind 'origin/feedback' by 12 commits, and can be fast-forwarded.
(use "git pull" to update your local branch)
```

Your number of commits will probably be different but the important things to see here is that it says `On branch feedback` so that you know you're not deleting the `main` copy of your work and `Your branch is behind origin/feedback` to know that reverting worked.

Now to make GitHub match your reverted local copy.

```
git push origin -f
```

and you'll get something like this to know that it worked

```
Total 0 (delta 0), reused 0 (delta 0)
To https://github.com/rhodyprog4ds/portfolio-brownsarahm.git
 + f301d90...822cfe5 feedback -> feedback (forced update)
```

Again, the numbers will be different and it will be your url, not mine.

Now back on GitHub, in your browser, click on the code tab. It should look something like this now. Notice that it says, "This branch is 11 commits behind main" your number will be different but it should be 1 less than the number you had when you checked `git status`. This is because we reverted the changes you made to main (11 for me) and the 1 commit for merging main into feedback. Also the last commit (at the top, should say "Setting up GitHub Classroom Feedback").

[rhodyprog4ds / portfolio-brownsarahm](#) Private

generated from rhodyprog4ds/portfolio

[Code](#) [Issues](#) [Pull requests](#) [Actions](#) [Projects](#) [Wiki](#) [Security](#) [Insights](#) [Settings](#)

[feedback](#) 5 branches 1 tag [Go to file](#) [Add file](#) [Code](#)

This branch is 11 commits behind main. [Pull request](#) [Compare](#)

Author	Commit Message	Date	Commits
brownsarahm	Setting up GitHub Classroom Feedback	822cfe5 3 days ago	3 commits
	.github	GitHub Classroom Feedback	3 days ago
	about	Initial commit	3 days ago
	template_files	Initial commit	3 days ago
	.gitignore	Initial commit	3 days ago
	README.md	Initial commit	3 days ago

Now, you need to recreate your Pull Request, click where it says pull request.

[rhodyprog4ds / portfolio-brownsarahm](#) Private

generated from rhodyprog4ds/portfolio

[Code](#) [Issues](#) [Pull requests](#) [Actions](#) [Projects](#) [Wiki](#) [Security](#) [Insights](#) [Settings](#)

[feedback](#) 5 branches 1 tag [Go to file](#) [Add file](#) [Code](#)

This branch is 11 commits behind main. [Pull request](#) [Compare](#)

Author	Commit Message	Date	Commits
brownsarahm	Setting up GitHub Classroom Feedback	822cfe5 3 days ago	3 commits
	.github	GitHub Classroom Feedback	3 days ago
	about	Initial commit	3 days ago
	template_files	Initial commit	3 days ago
	.gitignore	Initial commit	3 days ago
	README.md	Initial commit	3 days ago

It will say there isn't anything to compare, but this is because it's trying to use `feedback` to update `main`. We want to use `main` to update `feedback` for this PR. So we have to swap them. Change base from `main` to `feedback` by clicking on it and choosing `feedback` from the list.

[Skip to main content](#)

[rhodyprog4ds / portfolio-brownsarahm](#) Private [Unwatch](#)

generated from [rhodyprog4ds/portfolio](#)

---

## Comparing changes

Choose two branches to see what's changed or to start a new pull request. If you need to, you can also [compare across forks](#).

base: main ▾ ← compare: feedback ▾

Choose a base ref

Find a branch

Branches Tags

✓ main default

feedback

gh-pages

someOtherBranch

There isn't anything to compare.

Get up to date with all commits from **feedback**. Try [switching the base](#) for your comparison.

Up to date with all commits from **feedback**. Try [switching the base](#) for your comparison.

Then change the compare [feedback](#) on the right to [main](#). Once you do that the page will change to the “Open a Pull Request” interface.

## Open a pull request

Create a new pull request by comparing changes across two branches. If you need to, you can also [compare across forks](#).

A screenshot of a GitHub pull request merge interface. At the top, it shows the base branch as 'feedback' and the compare branch as 'main'. A green checkmark indicates that the branches are 'Able to merge'. The main area is titled 'Feedback' and contains a text input field with the placeholder 'Leave a comment'. Below the input field is a note saying 'Attach files by dragging & dropping, selecting or pasting them.' On the right side of the feedback area, there are several icons for rich text editing, including bold, italic, and code block symbols, along with other standard document tools like alignment and lists.

Make the title “Feedback” put a note in the body and then click the green “Create Pull Request” button.

Now you're done!

[Skip to main content](#)

If you have trouble, create an issue and tag [@rhodyprog4ds/fall20instructors](#) for help.

## For an Assignment, should we make a new branch for every assignment or do everything in one branch?

Doing each new assignment `in` its own branch `is` best practice. In a typical software development flow once the

## Other Course Software/tools

### Courseutils

This is how your badge issues are created. It also has some other utilities for the course. It is open source and questions/issues should be posted to its [issue tracker](#)

### Jupyterbook

### Glossary

#### 💡 Tip

We will build a glossary as the semester goes on. When you encounter a term you do not know, create an issue to ask for help, or contribute a PR after you find the answer.

#### **absolute path**

the path defined from the root of the system

#### **add (new files in a repository)**

the step that stages/prepares files to be committed to a repository from a local branch

#### **bitwise operator**

an operation that happens on a bit string (sequence of 1s and 0s). They are typically faster than operations on whole integers.

#### **bitwise operator**

an operation that happens on a bit string (sequence of 1s and 0s). They are typically faster than operations on whole integers.

#### **Compiled Code**

code that is put through a compiler to turn it into lower level assembly language before it is executed. must be compiled and re-executed everytime you make a change.

#### **directory**

a collection of files typically created for organizational purposes

the concept that the decimal can move within the number (ex. scientific notation; you move the decimal based on the exponent on the 10). can represent more numbers than a fixed point number.

### **fixed point number**

the concept that the decimal point does not move in the number (the example in the notes where if we split up a bit in the middle and one half was for the decimal and the other half was for the whole number. Cannot represent as many numbers as a floating point number.

### **.gitignore**

a file in a git repo that will not add the files that are included in this .gitignore file. Used to prevent files from being unnecessarily committed.

### **git**

a version control tool; it's a fully open source and always free tool, that can be hosted by anyone or used without a host, locally only.

### **git objects**

something (a file, directory) that is used in git; has a hash associated with it

### **GitHub**

a hosting service for git repositories

### **Git Plumbing commands**

low level git commands that allow the user to access the inner workings of git.

### **Git Workflow**

a recipe or recommendation for how to use Git to accomplish work in a consistent and productive manner

### **HEAD**

the branch that is currently being checked out (think of the current branch)

### **merge**

putting two branches together so that you can access files in another branch that are not available in yours

### **hash function**

the actual function that does the hashing of the input (a key, an object, etc.)

### **hashing**

putting an input through a function and getting a different output for every input (the output is called a hash; used in hash tables and when git hashes commits).

### **interpreted code**

code that is directly executed from a high level language. more expensive computationally because it cannot be optimized and therefore can be slower.

### **integrated development environment**

also known as an IDE, puts together all of the tools a developer would need to produce code (source code editor, debugger, ability to run code) into one application so that everything can be done in one place. can also have extra features such as

## **Linker**

a program that links together the object files and libraries to output an executable file.

## **path**

the “location” of a file or folder(directory) in a computer

## **pull (changes from a repository)**

download changes from a remote repository and update the local repository with these changes.

## **push (changes to a repository)**

to put whatever you were working on from your local machine onto a remote copy of the repository in a version control system.

## **relative path**

the path defined **relative** to another file or the current working directory

## **repository**

a project folder with tracking information in it in the form of a .git file

## **ROM (Read-Only Memory)**

Memory that only gets read by the CPU and is used for instructions

## **SHA 1**

the hashing function that git uses to hash its functions (found to have very serious collisions (two different inputs have same hashes), so a lot of software is switching to SHA 256)

## **shell**

a command line interface; allows for access to an operating system

## **ssh**

allows computers to safely connect to networks (such as when we used an ssh key to clone our github repos)

## **templating**

templating is the idea of changing the input or output of a system. For instance, the Jupyter book, instead of outputting the markdown files as markdown files, displays them as HTML pages (with the contents of the markdown file).

## **terminal**

a program that makes shell visible for us and allows for interactions with it

## **tree objects**

type of git object in git that helps store multiple files with their hashes (similar to directories in a file system)

## **yml**

see YAML

## **YAML**

a file specification that stores key-value pairs. It is commonly used for configurations and settings.

This section is for materials that are not specific to this course, but are likely useful. They are not generally required readings or installs, but are options or advice I provide frequently.

## on email

- how to e-mail professors

## How to Study in this class

In this page, I break down how I expect learning to work for this class.

Begin a great programmer does not require memorizing all of the specific commands, but instead knowing the common patterns and how to use them to interpret others' code and write your own. Being efficient requires knowing how to use tools and how to let the computer do tedious tasks for you. This is how this course is designed to help you, but you have to get practice with these things.

Using reference materials frequently is a built in part of programming, most languages have built in help as a part of the language for this reason. These tools can help you when you are writing code and forget a specific bit of syntax, but these tools will not help you *read* code or debug environment issues. You also have to know how to effectively use these tools.

Knowing the common abstractions we use in computing and recognizing them when they look a little bit differently will help you with these more complex tasks. Understanding what is common when you move from one environment to another or to This course is designed to have you not only learn the material, but also to build skill in learning to program. Following these guidelines will help you build habits to not only be successful in this class, but also in future programming.

## Why this way?

Learning requires iterative practice. In this class, you will first get ready to learn by preparing for class. Then, in class, you will get a first experience with the material. The goal is that each class is a chance to learn by engaging with the ideas, it is to be a guided inquiry. Some classes will have a bit more lecture and others will be all hands on with explanation, but the goal is that you *experience* the topics in a way that helps you remember, because being immersed in an activity helps brains remember more than passively watching something. Then you have to practice with the material

Preparing for class will be activities that help you bring your prior knowledge to class in the most helpful way, help me mee

You will be making a lot of documentation of bits, in your own words. You will be directed to try things and make notes. This based on a recommended practices from working devs to [keep a notebook]](<https://blog.nelhage.com/2010/05/software-and-lab-notebooks/>) or keep a blog and notebook.

## Learning in class

### Important

My goal is to use class time so that you can be successful with *minimal frustration* while working outside of class time.

Programming requires both practical skills and abstract concepts. During class time, we will cover the practical aspects and

[Skip to main content](#)

Learning to debug something you've never encountered before and setting up your programming environment, for example, are *high frustration* activities, when you're learning, because you don't know what you don't know. On the other hand, diving deeper into options and more complex applications of what you have already seen in class, while challenging, is something I'm confident that you can all be successful at with minimal frustration once you've seen basic ideas in class. My goal is that you can repeat the patterns and processes we use in class outside of class to complete assignments, while acknowledging that you will definitely have to look things up and read documentation outside of class.

Each class will open with some time to review what was covered in the last session before adding new material.

To get the most out of class sessions, you should have a laptop with you. During class you should be following along with Dr. Brown. You'll answer questions on Prismia chat, and when appropriate you should try running necessary code to answer those questions. If you encounter errors, share them via Prismia chat so that we can see and help you.

## After class

After class, you should practice with the concepts introduced.

This means reviewing the notes: both yours from class and the annotated notes posted to the course website.

When you review the notes, you should be adding comments on tricky aspects of the code and narrative text between code blocks in markdown cells. While you review your notes and the annotated course notes, you should also read the documentation for new modules, libraries, or functions introduced in that class.

If you find anything hard to understand or unclear, write it down to bring to class the next day or post an issue on the course website.

## GitHub Interface reference

This is an overview of the parts of GitHub from the view on a repository page. It has links to the relevant GitHub documentation for more detail.

## Top of page

The very top menu with the GitHub logo in it has GitHub level menus that are not related to the current repository.

## Repository specific page

The screenshot shows the top portion of a GitHub repository page. At the top left is the GitHub logo. To its right are several navigation links: Code, Issues, Pull Requests, Actions, Projects, Security, Insights, and Settings. Below this is a large rectangular area containing repository information. At the top of this area, the text "This is the main view of the project" is displayed. To the left, there's a "Branch menu & info, file action buttons, download options (green code button)". To the right, there's a "About" section with basic facts about the repo, often including a link to documentation. At the bottom left of this area, there's a "File panel". At the bottom right, there's a note stating "Releases, Packages, and Environments are optional". At the very bottom center of the page, there's a link "Skip to main content".

If there are actions on the repo, there will be a red x or a green check to indicate that if it failed or succeeded on that commit.

Releases mark certain commits as important and give easy access to that version. They are related to git tags

Packages are out of scope for this course. GitHub helps you manage distributing your code to make it easier for users.

Environments are a tool for dependency management. We will cover things that help you know how to use this feature indirectly, but probably will not use it directly in class. This would be eligible for a build badge.

The bottom of the right panel has information about the languages in the project

the header in this area lists who made the last commit, the message of that commit, the short hash, date of that commit and the total number of commits to the project.

If there are actions on the repo, there will be a red x or a green check to indicate that if it failed or succeeded on that commit. ^^^ file list: a table where the first column is the name, the second column is the message of the last commit to change that file (or folder) and the third column is when is how long ago/when that commit was made

README file

## Language/Shell Specific References

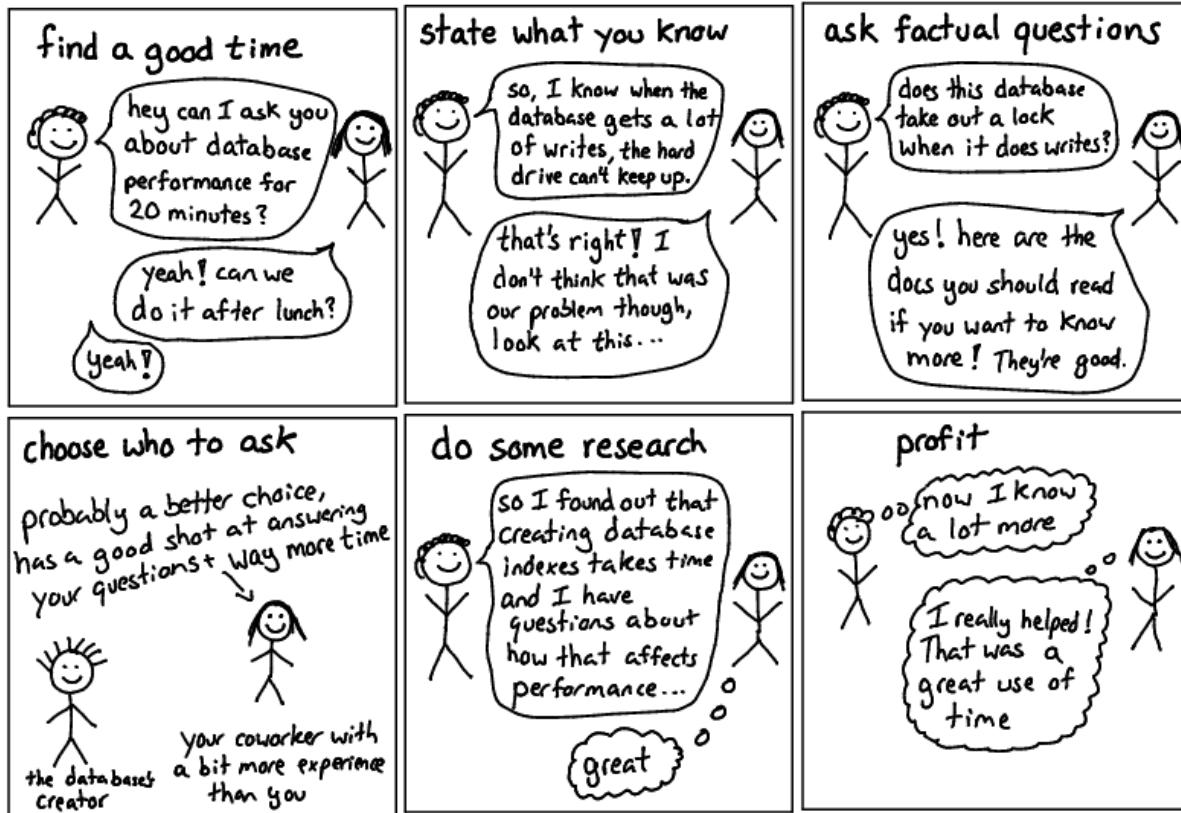
- bash
- C
- Python

## Getting Help with Programming

This class will help you get better at reading errors and understanding what they might be trying to tell you. In addition here are some more general resources.

## Asking Questions

# asking good questions



One of my favorite resources that describes how to ask good questions is [this blog post](#) by Julia Evans, a developer who writes comics about the things she learns in the course of her work and publisher of wizard zines.

## Describing what you have so far

Stackoverflow is a common place for programmers to post and answer questions.

As such, they have written a good guide on [creating a minimal, reproducible example](#).

Creating a minimal reproducible example may even help you debug your own code, but if it does not, it will definitely make it easier for another person to understand what you have, what your goal is, and what's working.

Not

A fun  
debug

## Getting Organized for class

The only **required** things are in the Tools section of the syllabus, but this organizational structure will help keep you on top of what is going on.

Your username will be appended to the end of the repository name for each of your assignments in class.

## File structure

I recommend the following organization structure for the course:

```
CSC310
|- notes
|- portfolio-username
|- 02-accessing-data-username
|- ...
```

This is one top level folder will all materials in it. A folder inside that for in class notes, and one folder per repository.

Please **do not** include all of your notes or your other assignments all inside your portfolio, it will make it harder to grade.

## Finding repositories on github

Each assignment repository will be created on GitHub with the [rhydyp4ds](#) organization as the owner, not your personal account. Since your account is not the owner, they do not show on your profile.

Your assignment repositories are all private during the semester. At the end, you may take ownership of your portfolio[^pttrans] if you would like.

If you go to the main page of the [organization](#) you can search by your username (or the first few characters of it) and see only your repositories.

### ⚠ Warning

Don't try to work on a repository that does not end in your username; those are the template repositories for the course and you don't have edit permission on them.

## More info on cpus

Resource	Level	Type	Summary
What is a CPU, and What Does It Do?	1	Article	Easy to read article that explains CPUs and their use. Also touches on "buses" and GPUs.
Processors Explained for Beginners	1	Video	Video that explains what CPUs are and how they work and are assembled.
The Central Processing Unit	1	Video	Video by Crash Course that explains what the Central Processing Unit (CPU) is and how it works.

## Windows Help & Notes

This is GitBash telling you that git is helping. Windows uses two characters for a new line `CR` (carriage return) and `LF` (line feed). Classic Mac Operating system used the `CR` character. Unix-like systems (including MacOS X) use only the `LF` character. If you try to open a file on Windows that has only `LF` characters, Windows will think it's all one line. To help you, since git knows people collaborate across file systems, when you check out files from the git database (`.git/` directory) git replaces `LF` characters with `CRLF` before updating your working directory.

When working on Windows, when you make a file locally, each new line will have `CRLF` in it. If your collaborator (or server, eg GitHub) runs not a unix or linux based operating system (it almost certainly does) these extra characters will make a mess and make the system interpret your code wrong. To help you out, git will automatically, for Windows users, convert `CRLF` to `LF` when it adds your work to the index (staging area). Then when you push, it's the compatible version.

[git documentation of the feature](#)