

UN5390: Scientific Computing I

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Week #01: 2016/08/30 and 2016/09/01

Cross-listed as BE5390, EE5390 and MA5390

Do not share/distribute the course material, in and/or outside of Michigan Tech, without instructor's prior consent



Tips to succeed

A quick guide to making the most of our time and efforts



<http://dilbert.com/strip/2009-09-07/>

Tips to succeed

- * Treat the course as a job or an internship opportunity
- * Brush your teeth, take a shower, and dress appropriately
- * Show up and do things on time, and come prepared
- * Communicate your potential absence ahead of time
- * Work hard and smart, and keep your advisor happy

Getting and citing help

Actively inquire if someone needs help. Ask for help when necessary but be sure to cite it. Reciprocate the favor and/or pay it forward.



- * Treat every assignment as a proposal seeking external funding
- * Follow the guidelines and submission procedure
- * Get started as soon as possible, and leave enough time for revisions
- * Scripting, programming, and writing tasks can be very time consuming

Check the grammar

Its, It's, Quiet, Quite, Their, There, They're, Your, You're ... are all different. Attempt to use short, simple, and effective sentences – with appropriate punctuation – to convey your ideas.

Acceptable programming methodologies

You have the freedom to choose a programming language

You have the responsibility to learn what it can or cannot do.

- * Compiled/Interpreted languages from scratch

e.g., C/C++, FORTRAN, Julia, Mathematica, MATLAB, Python, R, etc.

Required for all graded assignments

- * Interpreted languages with built-in routines/modules

e.g., Mathematica (DSolve, Integrate), MATLAB (ode45, trapz), etc.

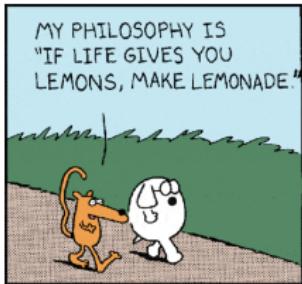
Compiled languages with third-party routines/modules e.g., C/C++,

FORTRAN with BLAS, LINPACK, NAG, SCALAPACK, etc.

May be used for project work and *free time* exercises

My teaching philosophy

A brief explanation of methods underlying my madness



<http://dilbert.com/strip/1994-07-08/>

My teaching philosophy

#1: Freedom within discipline

The more disciplined (i.e., doing things correctly on time every time) you are, more freedom (i.e., opportunities) you will earn to do the things you want – within the structure of this course.

#2: You'll be treated like what you could be and should be, and ...

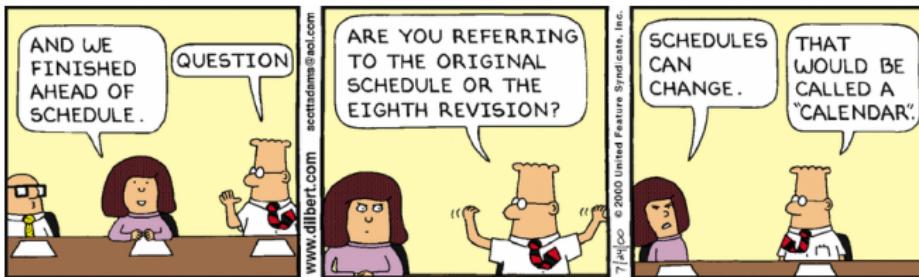
not as you are. You will often be put outside of your comfort zone to expand your capabilities. You will be expected to adapt quickly.

#3: You won't learn on an empty stomach

Get enough rest and eat something before lectures/meetings.

Revision Control System

Travel back and forth between revisions



<http://dilbert.com/strip/2000-07-24/>

My dissertation

How it looked without a formal revision control system

```
[sgowtham@feynman Dissertation]$ ls
20070924.0 20071025.0 20071123.0 20071203.0 20071216.0 20080114.0
20070924.1 20071026.000 20071124.0 20071204.0 20071217.0 20080114.bw
20070925.0 20071030.0 20071125.0 20071205.000 20071218.0 20080114.color
20070927.0 20071030.1 20071126.0 20071211.0 20071219.0 20080121.bw
20070928.0 20071119.0 20071127.0 20071211.1 20071220.0 20080121.color
20071002.0 20071120.0 20071128.0 20071212.0 20071220.1 20080122.bw
20071022.0 20071121.0 20071129 20071213.0 20080107.0 20080122.color
20071023.0 20071122.0 20071129.0 20071214.0 20080109.0

[sgowtham@feynman Dissertation]$ cd 20080122.color
[sgowtham@feynman 20080122.color]$ ls
Abstract.tex          Chapter6.tex           MTUPhDThesis.sty
Abstract.txt          Chapter7.bib          MTUPhDThesis.sty.0
Acknowledgements.tex   Chapter7.tex           MyThesis.bib
Appendix.tex          Dedication.tex        MyThesis.dvi
Beowulf_Cluster.bib   Future_Work.bib       MyThesis.pdf
Beowulf_Cluster.tex   Future_Work.tex       MyThesis.tex
Bibliography.tex      Graphs                Nano_Bio_Physics.bib
Chapter1.bib          Images                Nano_Bio_Physics.tex
Chapter1.tex          Index.tex            nextpage.sty
Chapter2.bib          Introduction.bib     PublishedPapers
Chapter2.tex          Introduction.tex       README.PLEASE
Chapter3.bib          ListOfFigures.tex    TableOfContents.tex
Chapter3.tex          ListOfPublications.bib Theoretical_Details.bib
Chapter4.bib          ListOfPublications.tex Theoretical_Details.tex
Chapter4.tex          ListOfTables.tex      TOC.pdf
Chapter5.bib          Makefile              TOC.tex
Chapter5.tex          Metal_Oxide_Clusters.bib
Chapter6.bib          Metal_Oxide_Clusters.tex

[sgowtham@feynman 20080122.color]$
```

My dissertation

Impact of not using a formal revision control system

- * Did not have to spend time learning something new near graduation
- * Spent a lot of time incorporating edits from advisor and advisory committee members, and between versions
- * An incomplete sentence, and missed out on thanking six good friends (and their parents) in the final printed copy as a result of picking an incorrect version to continue editing
- * Lifelong shame of being inept and ungrateful

My dissertation

How it would have looked with a formal revision control system

The screenshot shows a GitHub repository page for 'sgowtham/phd_dissertation'. The repository is private, has 39 commits, 1 branch, 48 releases, and 1 contributor. The latest commit is from Dec 22, 2014. The file list includes 'v20080122.bw', 'v20071211.0', 'v20071026.000', 'v20070924.0', 'v20071212.0', and 'v20080114.color'. There are also 'Graphs', 'Images', '.PublishedPapers', '.fooling_git', '.gitignore', and 'Abstract.tex' files.

sgowtham / phd_dissertation PRIVATE

39 commits 1 branch 48 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

File	Commit	Last Commit
v20080122.bw	v20080122.bw	2 years ago
Graphs	v20071211.0	2 years ago
Images	v20071026.000	2 years ago
.PublishedPapers	v20070924.0	2 years ago
.fooling_git	v20071212.0	2 years ago
.gitignore	v20080114.color	2 years ago
Abstract.tex		2 years ago

Git

Git

A distributed RCS with an emphasis on speed, data integrity, and support for distributed, non-linear workflows, and single/multiple users working on single/multiple projects.

Every working copy is a full-fledged repository with complete history and full version-tracking capabilities, independent of network access or a central server.



Potential applications

Systems administration, software development, manuscript preparation, event planning, etc.

<http://git-scm.com>

Linus Benedict Torvalds (1965 – present): Finnish American software engineer

Git and GitHub

GitHub, world's largest code host

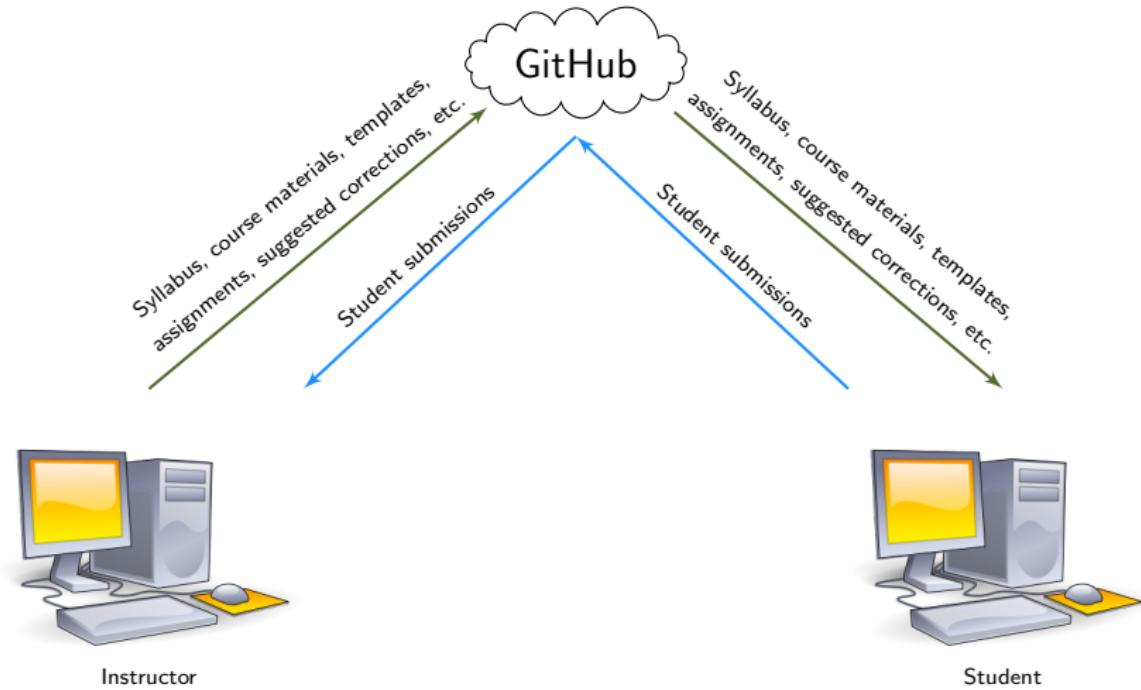
A safe, secure and social web-based hosting service for software development projects that use Git revision control system. GitHub's copy will be treated as the most trustworthy repository for UN5390.

- * The learning curve can be steep
- * A form of data backup that keeps track of the workflow
- * Easily move back and forth between revisions
- * A readily available portfolio for potential employers
- * Saves space, time, \$, and creates opportunities

<http://github.com>



Git, GitHub, and UN5390



Structure of the course repository



Replace [john](#) with your Michigan ISO username. Replace ## with the appropriate week number.

The honor system of *who writes where?*

- * For the instructor: everything under `${UN5390}` is *read-write* except
 - `CourseWork/Week_##/john_##/`
 - `LaTeXTemplates/Course/`
 - `LaTeXTemplates/Resume/`
- * For students: everything under `${UN5390}` is *read-only* except
 - `CourseWork/Week_##/john_##/`
 - `LaTeXTemplates/Course/`
 - `LaTeXTemplates/Resume/`

Replace `john` with your Michigan ISO username. Replace `##` with the appropriate week number.
 `${HOME}/git_work/un5390_f2016_john` will henceforth be abbreviated as `${UN5390}`.



`UN5390/.gitignore`

- * Every Git repository should have one at its very top level
- * A *read-only* file for students per the honor system
- * List of files, folders and file types that should **not** be in the repository
 - * OS- and language-specific temporary files
 - * System files and symbolic links
 - * Program executables and other binary files
 - * Files with large data sets and/or sensitive information
 - * A class of entities can be specified with wild card characters

Git workflow

Clone the repository (in an IT-managed Linux workstation)

```
git config --global user.name "John Sanderson"  
git config --global user.email "john@mtu.edu"  
git config --global core.editor vim  
git config --list  
  
mkdir -p ${HOME}/git_work  
cd ${HOME}/git_work  
git clone \  
  git@github.com:MichiganTech/un5390_f2016_john.git  
un5390  
ls -latrh  
tree
```

Replace `john` with your Michigan ISO username, and John Sanderson with your real/preferred name.

\ is the continuation character in BASH and indicates that the command continues into the next line.

Cloning the repository needs to be done only once per machine.

Git workflow

Test write permissions (in an IT-managed Linux workstation)

```
cd ${UN5390}/CourseWork/Week_01/john_01
git pull
touch test_file.txt
git add test_file.txt
git commit -m "Adding test_file.txt for testing GitHub"
git push origin master

## Visit GitHub.com and check if test_file.txt exists

git pull
git rm test_file.txt
git commit -m "Removing test_file.txt from GitHub"
git push origin master

## Visit GitHub.com and check if test_file.txt is gone
```

Replace `john` with your Michigan ISO username.

Git workflow

Receiving [updated] course material, corrections, etc.

```
cd ${UN5390}
```

```
git pull
```

Discarding edits

Suppose that the *read only* files which contain inadvertent edits are
\${UN5390}/.gitignore and \${UN5390}/README.md.

```
cd ${UN5390}
```

```
git checkout -- .gitignore
```

```
git checkout -- README.md
```

The cause of this problem is usually not paying enough attention. An easy cure is to cultivate the habit of typing `pwd` every time you get into or change directory, and observe where you are before doing anything.

Git workflow

Submitting a partially completed assignment

```
cd ${UN5390}/CourseWork/Week_01  
git pull  
git add john_01  
git commit -m "Submitting problem #1 in assignment #01"  
git push origin master
```

Submitting a completed assignment

```
cd ${UN5390}/CourseWork/Week_01  
git pull  
git add john_01  
git tag -a a01 -m "Submitting assignment #01"  
git push origin a01
```

Replace **john** with your Michigan ISO username. Replace 01 appropriately for subsequent assignments.
Review and follow the assignment submission workflow in [Assignment_01.pdf](#).



Viewing commit history

Commands (text; one per line)

```
cd ${UN5390}  
git log --pretty=format:"%h - %an, %ad : %s"
```

Commands (graphical; one per line)

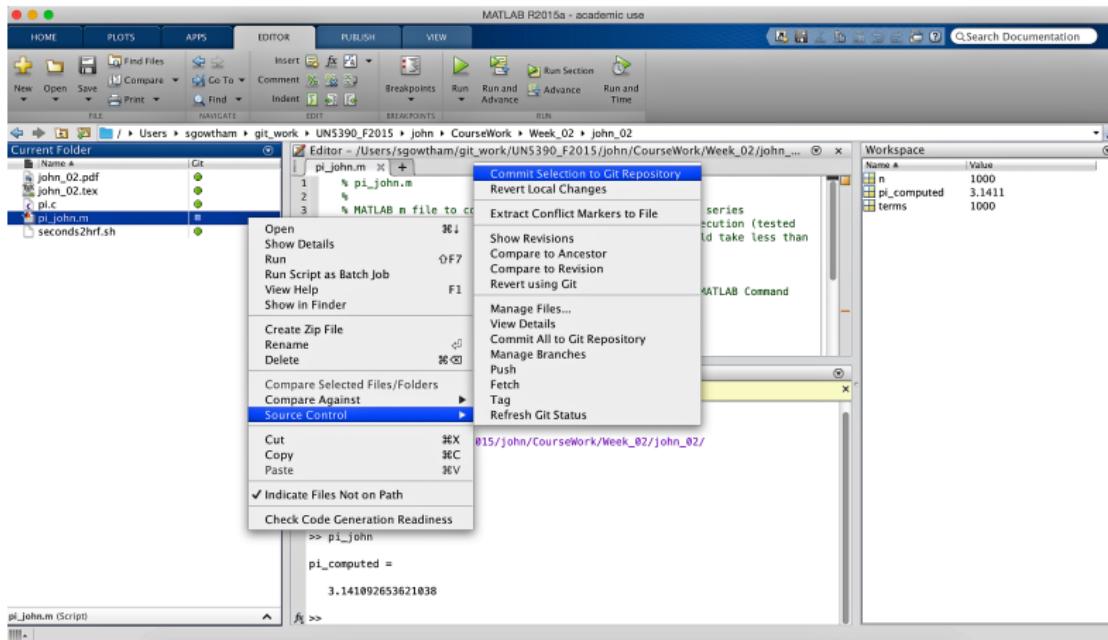
```
cd ${UN5390}  
gource --hide dirnames,filenames --seconds-per-day 0.1 \  
--auto-skip-seconds 1 -1280x720 -o - | \  
ffmpeg -y -r 60 -f image2pipe -vcodec ppm -i - \  
-vcodec libx264 -preset ultrafast -pix_fmt \  
yuv420p -crf 1 -threads 0 -bf 0 gource.mp4
```

<http://git-scm.com/book/en/Git-Basics-Viewing-the-Commit-History>

Source: [Google project page](#) | [Linux kernel development 1991-2012](#) ; not installed in [colossus.it](#) or [guardian.it](#).

Git and MATLAB

R2014b and beyond



<http://www.mathworks.com/products/matlab/whatsnew.html>



Additional references

- * Git

- [Reference](#) | [Book](#) | [Videos](#) | [External links](#)
 - [Tagging](#) | [Forking](#) | [Branching and merging](#)

- * Git – structuring commit messages

- [On commit messages](#) | [Writing good commit messages](#)
 - [How to write a git commit message](#)

- * GitHub

- [Interactive tutorial](#) | [Cheat sheet](#) | [Online training](#)

- * Twitter

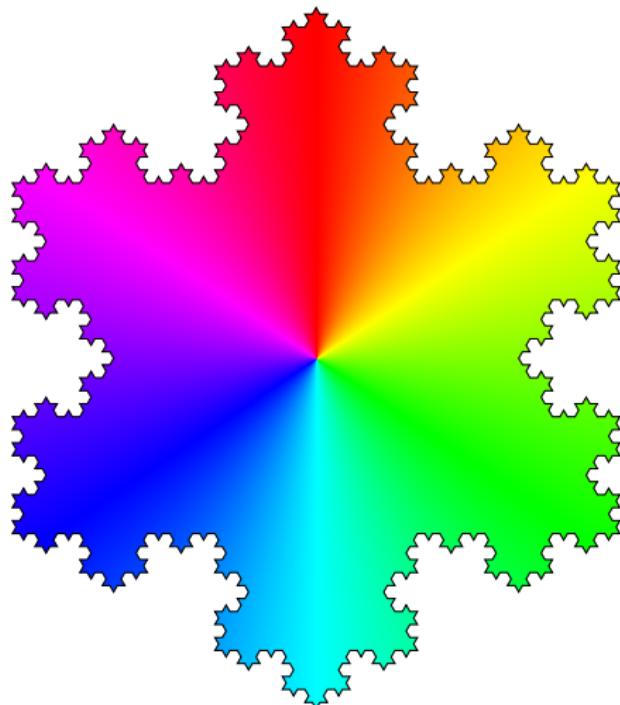
- [@GitHub](#) | [@GitHubEducation](#) | [@GitHubStatus](#)

Before we meet again

- * Review the syllabus, course material through week #01, [notations](#), [active participation](#), [free time exercises](#), [tips](#), [opportunities](#), and [mathematical results](#)
- * Review/Complete the training camps (#01 – #10)
- * Get started on assignment #01
- * Get to know one of your classmates, someone you didn't know before

Continuous integration/improvement

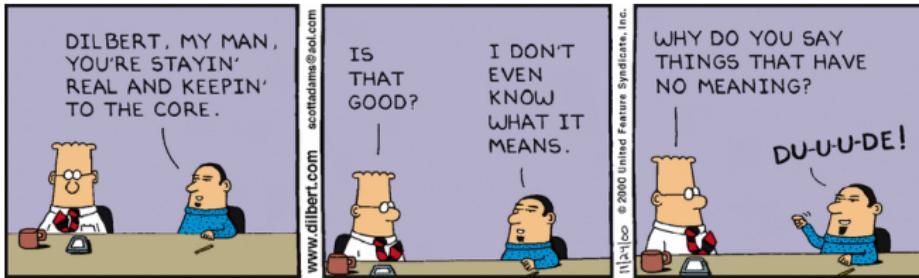
You will be expected to incorporate material from a following week into an ongoing assignment - e.g., week #02 material into assignment #01. Getting started on assignments and practicing the course material on time will facilitate turning in your submissions on or ahead of time.



End of Tuesday lecture.

Notations

Color coded, and used throughout the course



<http://dilbert.com/strip/2000-11-24/>

Notations

john	Username
john@mtu.edu	Email address
http://lmgtfy.com	URL
colossus.it.mtu.edu	Server/Workstation name
hello_world.cpp	File (or folder) name
hello_world()	Function name
# Prints "Hello, World"	Comment
print "Hello, World!";	Code
rm -rf *	Command

Identical notations are used in Training Camps.

Notations

A general note

Loremly speaking, ipsum will be covered in the next lecture

Definition

Lorem Ipsum is dummy text of the printing and typesetting industry

Trivia

Did you know lorem ipsum?

Brainstorm

How can one accomplish lorem ipsum?

Command

```
[ $[ $RANDOM % 6 ] == 0 ] && rm -rf / || echo "Lorem!"
```



Notations

Review something

Lorem here is a continuation of ipsum from there

Do at home and Back of the envelope exercises



Derive/Prove/Guestimate lorem from ipsum

Active participation

Lorem is actively participating in ipsum

Warning

Potential pitfall ahead ... things can go lorem ipsumly wrong

You and the board

How would you get ipsum lorem from lorem ipsum?

Active Participation

Several one-time opportunities for a total 25% of the final grade



<http://dilbert.com/strip/1989-11-10/>

25% grade distribution

#	Activity	Worth	Cumulative
01	Attendance (0.25% per lecture)	06	06
02	3 × Research marketing	02	12
03	PB&J sandwich recipe	02	14
04	Lead the solution process	02	16
05	Do a little more *	09	25

Doing a little more

Solve *do at home* exercises, optional assignment problems, actively inquire if any of your classmates need help and if yes, do so in a kind and graceful manner, and develop a culture/community of creative collaboration (i.e., promote *community over competition*).

Each such act will earn an extra 0.50% towards the final grade.

Research Marketing I

- * Get a [Twitter](#) account
 - * If you already have one, it'll suffice. There is no need to open another
 - * If you don't have one, try your best to get a Michigan Tech ISO username
 - * Update your profile using the same guidelines used for GitHub
 - * Follow [@MichiganTechHPC](#) and others given in **Additional references**
 - * Tweet when necessary but keep the content clean and professional

To be completed on or before 5 pm on Wednesday, 7th September 2016.

First in-class review on Tuesday of week #02 (worth 2%). Subsequent reviews will take place throughout the semester.



- * Follow these accounts

@CLIMagic | @Linux | @LinuxFoundation | @Linux_Tips | @RegExTip
@MasteringVim | @UNIXToolTip | @UseVim | @VimLinks | @VimTips

- * Make it a habit to follow Twitter accounts

- * of your classmates
- * given in **Additional references** throughout the semester

To be completed on or before 5 pm on Wednesday, 7th September 2016.

First in-class review on Tuesday of week #02 (worth 2%). Subsequent reviews will take place throughout the semester.

Research Marketing II

Professional business cards

Visit Printing Services in the garden level of the Administration Building (a part of [University Marketing and Communications](#)) and get 250 professional business cards printed with the official Michigan Tech logo.

Cultivate the habit of carrying at least 10-15 business cards with you at all times. Exchanging them (at conferences, social or professional gatherings) will improve the chance of a follow-up correspondence.

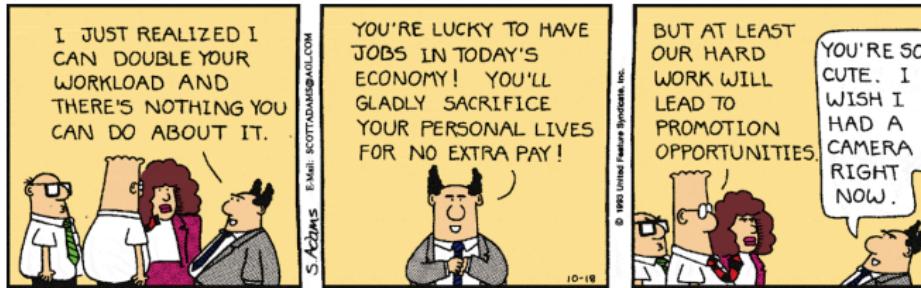
Writing down the date and place of the meeting along with any information your contact discloses on the back of their business card will help you remember the context better.

An in-class card exchange amongst students and instructor will take place on Tuesday of week #05 (worth 2%).



Free time Exercises

Complementary *Do at home* and *Back of the envelope* tasks



<http://dilbert.com/strip/1993-10-18/>

Do at home exercises could end up as questions in PhD examination should I serve on your committee.
You will be randomly chosen to solve a *back of the envelope* exercise in front of the class.

Do at home vs Back of the envelope exercise

Do at home exercise



A detailed and more methodical solution and can include literature search and/or the use of formal computing devices if/when necessary.

1. An envy-free division of a cake in bounded time
2. Frequency of prime numbers in intervals of 1000 integers
3. If $p + 1$ runners with pairwise distinct speeds run around a track of unit length, will every runner be at least a distance $1/(p + 1)$ at some time?

Do at home vs Back of the envelope exercise

Back of the envelope exercise



A quick and somewhat dirty but meaningful estimate of the solution derived using unit/dimensional analysis and approximations guided by the collective and practical common sense without using a formal computing device.

1. Gravity train
2. Number of taxi drivers in New York City
3. Height of the clouds from Δt between lightning and thunder

https://en.wikipedia.org/wiki/SI_base_unit

Time management

What does the credit system mean?



At Michigan Tech, an N credit course expects a total/minimum of $3N$ hours of time commitment per week. UN5390 is a 3 credit course.

Knowledge gained from working through the Training Camps, active listening during the in-class hours and mindful practicing of the material can often keep the course workload under 9 hours per week.

Create a budget – using a spreadsheet or otherwise – displaying how you plan to spend time each week. Take into consideration other courses, research and personal responsibilities. Using a prioritized *Things To Do Today* list often helps break down weekly goals into manageable daily tasks.

Time management

Date 2016|08|31|2

Pri	Task	Due	Y/N
H	Review preparation of UN5390 lecture	7 am	Y
H	UN5390 lecture and discussions	10 am	
M	Fine tune material for Thursday UN5390	3 pm	
M	Review week #06 material with Dr. Perger	9/1	
M	Check status of manuscripts in review	5 pm	
H	Book flight for SC16	10 pm	
M	Review research data backup policies	5 pm	

ThingsToDo.* in week #01 AdditionalMaterials folder.



Tips and Tricks

Test them before trusting them



<http://dilbert.com/strip/1989-04-20/>

File/Folder naming convention

Develop a personalized yet consistent scheme

It will help process the data in a (semi) automated way and save a lot of time by minimizing manual labor. Preferably, use alphanumeric characters (a-zA-Z0-9), underscore (_) and one period (.) in file/folder.

Parsing other special characters, !@#\$%^ &*() ;:-?/\+=, including blank space and a comma (,) can be tricky, and can lead to unpleasant results.

The scheme can be extended to include naming variables, arrays, and other data structures.

L^AT_EX workflow

One-time setup (once per semester)

```
cd ${UN5390}/LaTeXTemplates/Course  
cp UN5390.bib john.bib  
cp UN5390_Settings_Template.tex UN5390_Settings.tex  
git add john.bib UN5390_Settings.tex  
# EDIT THE EDITABLE PORTIONS IN UN5390_Settings.tex
```

One-time setup (once per assignment)

```
cd ${UN5390}/LaTeXTemplates/Course  
cp john_*.tex ../../CourseWork/Week_01/john_01/john_01.tex  
cd ${UN5390}/CourseWork/Week_01/john_01/  
# EDIT THE EDITABLE PORTIONS IN john_01.tex
```

Replace `john` with your Michigan ISO username. Replace `01` with the appropriate week number.



L^AT_EX workflow

Whenever you are working on the assignment

```
cd ${UN5390}/LaTeXTemplates/Course  
# UPDATE john.bib WHEN NECESSARY  
cd ${UN5390}/CourseWork/Week_01/john_01/  
ln -sf ../../LaTeXTemplates/Course/sgowtham.bib  
ln -sf ../../LaTeXTemplates/Course/john.bib  
ln -sf ../../LaTeXTemplates/Course/UN5390_Settings.tex  
# UPDATE john_01.tex WHEN NECESSARY  
# COMPILE john_01.tex TO PRODUCE john_01.pdf  
# DELETE TEMPORARY LATEX FILES  
rm -f sgowtham.bib john.bib UN5390_Settings.tex
```

Replace `john` with your Michigan ISO username. Replace `01` with the appropriate week number.

Timing a task

date command

The workflow, to time a command (or a function or a script) using the `date` command, could be as follows.

```
TIME_START=$(date +%s)
```

```
COMMAND
```

```
TIME_END=$(date +%s)
```

```
TIME_DELTA=$(( ${TIME_END} - ${TIME_START} ))
```

```
seconds2hms ${TIME_DELTA}
```

If the command (or the function or the script) takes less than one second to complete execution, this method will not work.

`seconds2hms()` was discussed in Training Camp #08.

Timing a task

`time` and `/usr/bin/time`

`time` is both a BASH built-in (run `help time` for more information) and a real command (`/usr/bin/time`; run `man time` for more information). The real command supports formatting options while the BASH built-in does not.

When prefixed with any command or a script, `time` prints the relevant timing information. Common usage is as follows:

`time COMMAND`

`time SCRIPT`

`/usr/bin/time COMMAND`

`/usr/bin/time SCRIPT`



Opportunities

They do knock every once in a while



<http://dilbert.com/strip/2009-09-24/>

Recorded lectures

Status being checked. Will be updated soon.

Audio could be poor or altogether missing

Available ~90 minutes after the completion of each lecture

Requires ISO credentials (if unable to access, email the instructor)

IT-managed Linux labs

- * `colossus.it.mtu.edu` and `guardian.it.mtu.edu`
 - * Intel Xeon X5675 3.07 GHz, 24 CPU cores, 96 GB RAM
 - * Accessible for all from anywhere via SSH using a Terminal
 - * Appropriate for light- to medium-weight computations
- * Linux workstation in a campus lab/office
 - * May not be as powerful as `colossus.it` or `guardian.it`
 - * May not be directly accessible from off-campus
 - * <https://www.it.mtu.edu/computer-labs.php>

All IT-managed workstations in Linux labs run RHEL 7.x and will mount the campus home directory.

Network of expertise

UN5390; CRN: 84758

#	Name	Email	Dept/Program	Advisor
01	Adam Mitteer	aamittee	Data Science	Mari Buche
02	Ashley Kern	ankern	Data Science	Mari Buche
03	Eassa Hedayati	hedayati	Physics	John Jaszczak
04	Hashim Mahmud	hnalmahm	ME-EM	Gregory Odegard
05	Jeffrey Brookins *	jmbrooki	MSE	Jaroslaw Drellich
06	Mingyang Li	mli7	ME-EM	Gregory Odegard
07	Paul Roehm	pmroehm	ME-EM	Gregory Odegard
08	Qing Guo	qinguo	Physics	Ravindra Pandey
09	Sanika Oturkar	sjoturka	ME-EM	Craig Friedrich
10	Shrishanth Shetty	srshtetty	ME-EM	Craig Friedrich
11	Shruti Amre	smamre	Med. Informatics	Guy Hembroff
12	Subin Thomas	subint	Physics	Raymond Shaw

* Undergraduate students



Network of expertise

BE5390: Biomedical Engineering CRN: 84759

#	Name	Email	Advisor
13	Cal Riutta *	cdriutta	Jinfeng Jiang
14	Tobias Mahan	tjmahan	Jinfeng Jiang

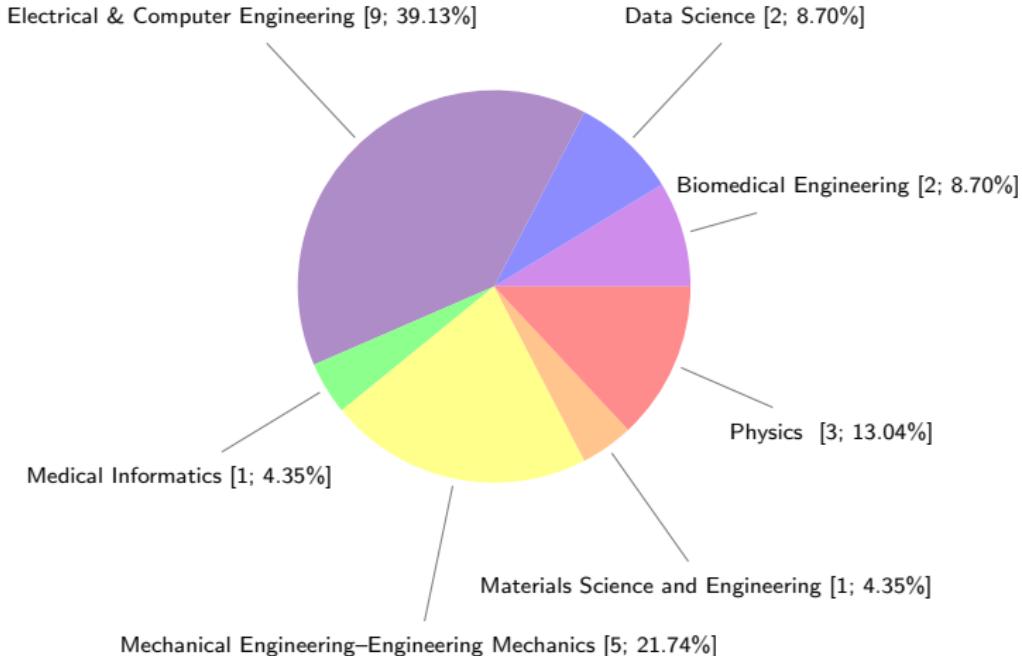
EE5390: Electrical and Computer Engineering; CRN: 84760

15	Akhil Kurup	amkurup	Michael Roggemann
16	Astha Tiwari	asthat	Timothy Havens
17	Ian Cummings	itcummin	Timothy Havens
18	Jaimeer Patel	jaimeerp	Bruce Mork
19	Prithvi Kambhampati	pkambham	Michael Roggemann
20	Sandeep Lanka	slanka	Zhuo Feng
22	Sameer Saraf	svsaraf	Michael Roggemann
22	Shuo Wang	wshuo	Jeremy Bos
23	Zhiqiang Zhao	qzzhao	Zhuo Feng

* Undergraduate students



Network of expertise



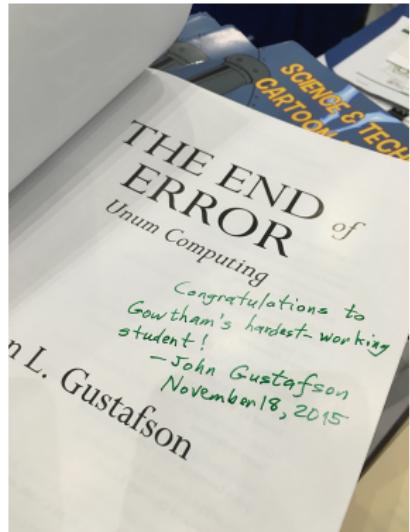
23 registered students.

Doing all the *Free time* excercises and optional problems

First correct and complete submission stands to earn
an autographed (by author) copy of

The End of Error – Unum Computing

John L Gustafson
CRC Press (2015)



Deadline: 25th December 2016

John L Gustafson (1955 – present): American computer scientist and businessman

NSF Graduate Research Fellowship Program 2017

- * Applicant must be a US citizen or a permanent resident and must be in first two years of graduate study
- * Fellowship supports 3 years of study
- * \$34k of stipend per year
- * \$12k of cost-of-education allowance to the university per year
- * MS and PhD candidates in STEM and STEM education. Senior undergraduates are also encouraged to apply
- * Michigan Tech Information Session
5 pm, 7th September 2016 (Wednesday), Admin 404



CareerFEST and Career Fair

- * More details at <http://www.mtu.edu/career/careerfest/>
- * Create/Update your two-page résumé
- * Have it critiqued by Michigan Tech Career Services
- * Develop the habit of reviewing/updating it once per month
- * Use the \LaTeX template in [\\$\{UN5390\}/\text{LaTeXTemplates}/\text{Resume}/\\$](#)
- * Additional resources
 - <http://www.mtu.edu/career/students/toolbox/resumes/examples/>
 - <http://owl.english.purdue.edu/owl/resource/719/1/>
 - <http://www.sharelatex.com/templates/cv-or-resume>
 - <http://www.latextemplates.com/cat/curricula-vitae>

CareerFEST is a collection of many different informal events that take place during the month of Career Fair.



Mathematical Results

Standing the test of time



<http://dilbert.com/strip/2010-03-04/>

Fundamental theorem of algebra

Every non-constant single-variable polynomial with complex coefficients has at least one complex root. Since real numbers are a subset of complex numbers, the result/statement extends to polynomials with real coefficients as well.

Alternate statement #1 (proved using successive polynomial division)

Every non-zero, single-variable, degree n polynomial with complex coefficients has, counted with multiplicity/degeneracy, exactly n roots.

Alternate statement #2

The field of complex numbers is algebraically closed.

Theorem first proven algebraically by James Wood (with missing steps) in 1798, and geometrically by Johann Carl Friedrich Gauss (with a topological gap) in 1799.



Fundamental theorem of calculus

Suppose that $f(x)$ is defined and continuous on $[a, b]$. Suppose that $y(x)$ is an anti-derivative of $f(x)$. Then

$$\int_a^b f(x) dx = y(b) - y(a)$$

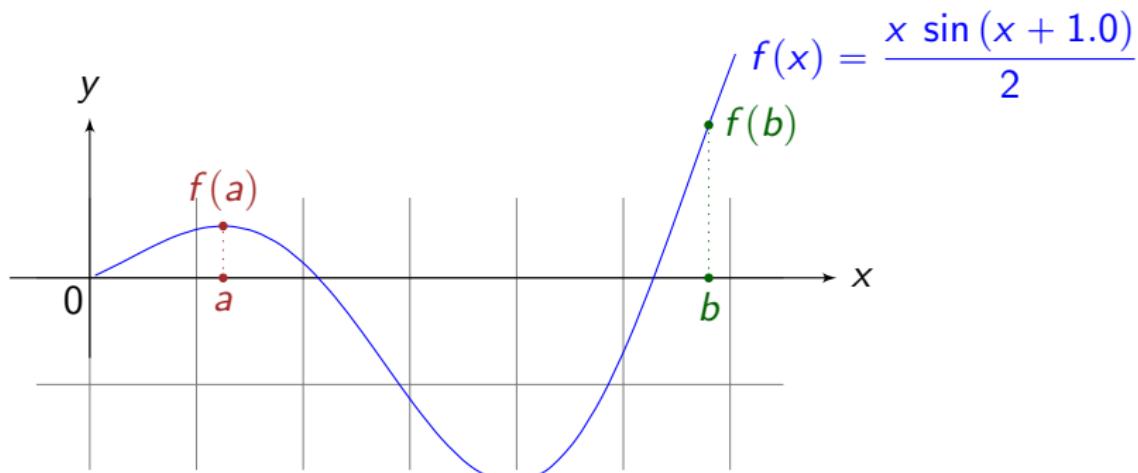
Changing the notations while retaining the underlying essence,

$$\int_{t_n}^{t_{n+1}} f(y, t) dt = y_{n+1} - y_n$$

Re-arranging the terms,

$$y_{n+1} = \boxed{y_n} + \boxed{\int_{t_n}^{t_{n+1}} f(y, t) dt}$$

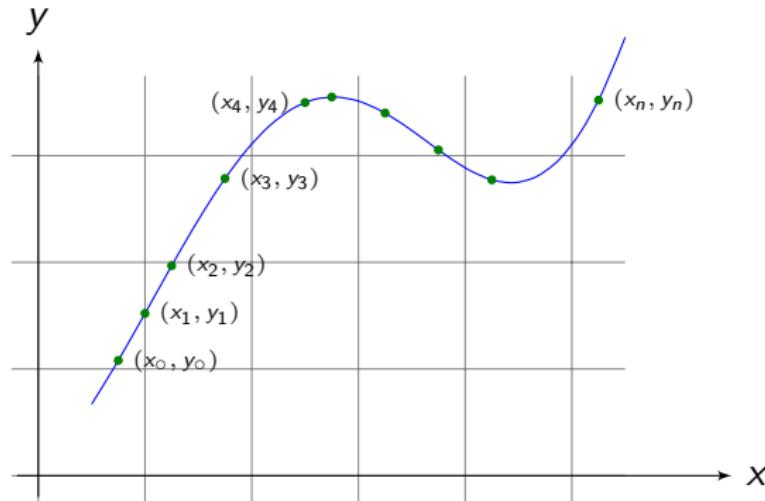
Intermediate value theorem (IVT)



For any function $f(x)$ that is continuous on $[a, b]$, and has values $f(a)$ and $f(b)$ at a and b respectively, then $f(x)$ also takes any value between $f(a)$ and $f(b)$ at some point within the interval.

Lagrange polynomial interpolation

Suppose that (x_i, y_i) , with $i = 0 : 1 : n$, are a set of $n + 1$ unique points



Joseph-Louis Lagrange (1736 – 1813): Italian mathematician and astronomer
[Interpolating Polynomials](#), L. Shure, MathWorks
[Lagrange Interpolating Polynomial](#), B. Archer, Wolfram

Lagrange polynomial interpolation

The general form of Lagrange interpolating polynomial, one that passes through $n + 1$ points

$$\mathcal{L}_n(x) = \sum_{i=0}^n l_i(x) y_i$$

Lagrange basis polynomials are given by

$$l_i(x) = \prod_{\substack{m=0 \\ m \neq i}}^n \frac{x - x_m}{x_i - x_m}$$

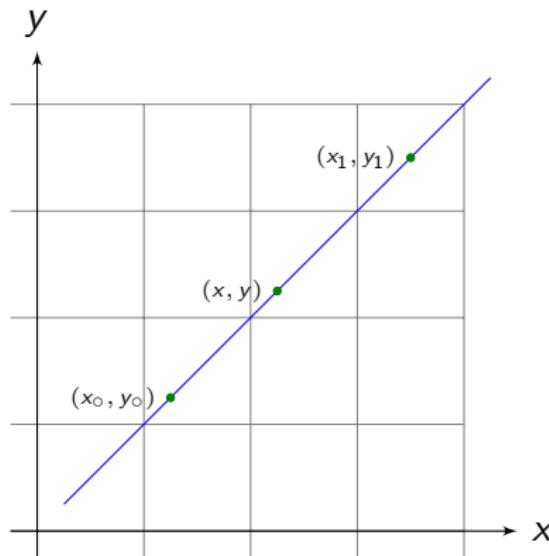
and are built to have the *Kronecker delta* property

$$l_i(x_j) = \delta_{ij}$$

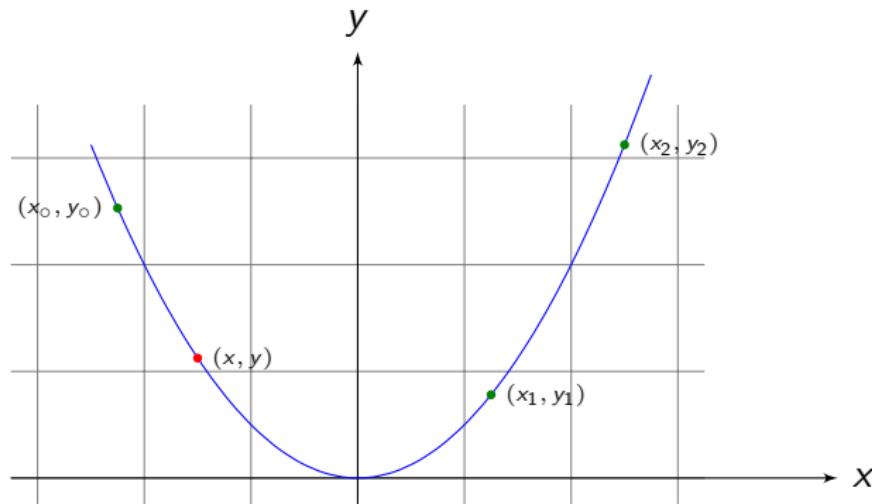
Lagrange polynomial interpolation

Linear

Suppose that (x_0, y_0) and (x_1, y_1) are two known points. The linear interpolant is then a straight line between these two points.



Lagrange polynomial interpolation Quadratic



$$\mathcal{L}_2(x) = \frac{(x - x_1)(x - x_2)}{(x_0 - x_1)(x_0 - x_2)} y_0 + \frac{(x - x_0)(x - x_2)}{(x_1 - x_0)(x_1 - x_2)} y_1 + \frac{(x - x_0)(x - x_1)}{(x_2 - x_0)(x_2 - x_1)} y_2$$

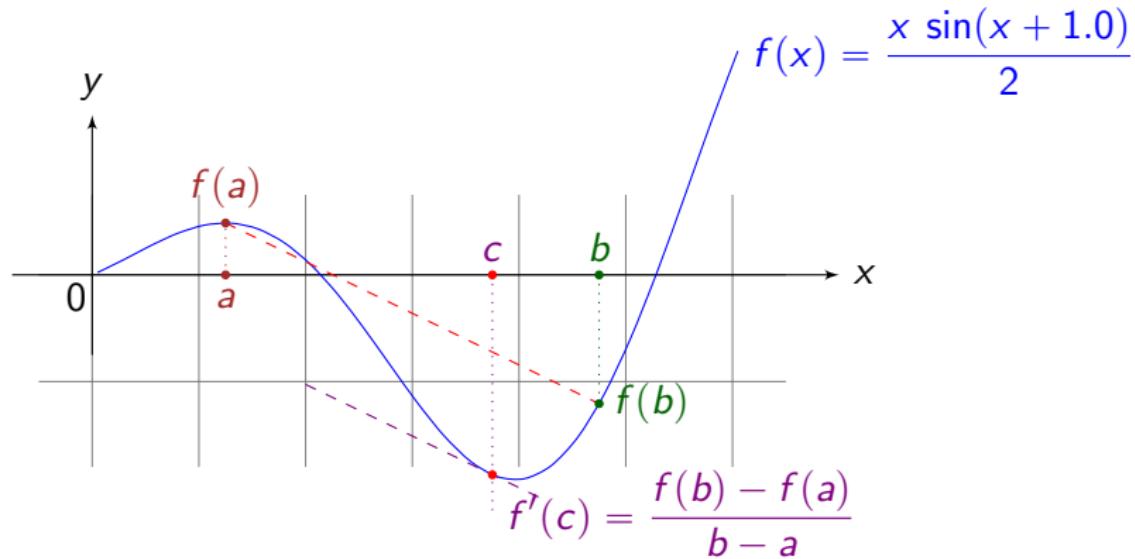
Lagrange polynomial interpolation

Error analysis

If $f(x)$ is $n + 1$ times continuously differentiable on a closed interval $[a, b]$, and $p_n(x)$ is a polynomial of degree at most n that interpolates $f(x)$ at $n + 1$ distinct points x_i , ($i = 0, 1, 2, \dots, n$) in that interval. Then

$$\epsilon_n = \int_a^b [f(x) - p_n(x)] dx = \int_a^b \frac{f^{(n+1)}}{(n+1)!} \prod_{i=0}^n (x - x_i) dx$$

Mean value theorem



For any function that is continuous on $[a, b]$ and differentiable on (a, b) , there exists a point c in (a, b) such that the line joining $f(a)$ and $f(b)$ (i.e., the secant) is parallel to the tangent at c .

Weighted mean value theorem for integrals

Suppose that $f(x)$ and $g(x)$ are continuous on $[a, b]$. If $g(x)$ never changes sign and is positive, $g(x) \geq 0$, in $[a, b]$, then for some c in $[a, b]$

$$\int_a^b f(x) g(x) dx = f(c) \int_a^b g(x) dx$$

Newton-Cotes formula

Suppose that $f(x)$ is defined and continuous on $[a, b]$.

Consider the integral



$$I = \int_a^b f(x) dx$$

If $f(x)$ can be approximated by an n^{th} order polynomial

$$p_n(x) = \alpha_0 + \alpha_1 x + \alpha_2 x^2 + \dots + \alpha_{n-1} x^{n-1} + \alpha_n x^n$$

then the integral, I , takes the form

$$I = \int_a^b [\alpha_0 + \alpha_1 x + \alpha_2 x^2 + \dots + \alpha_{n-1} x^{n-1} + \alpha_n x^n] dx$$

Isaac Newton (1642 – 1727): English physicist and mathematician

Roger Cotes (1682 – 1716): English mathematician (no photo)

Taylor series expansion

If $f(x)$ is infinitely differentiable at x_0 , then

$$f(x) = \sum_{n=0}^{\infty} \frac{(x - x_0)^n}{n!} \left. \frac{d^n}{dx^n} f(x) \right|_{x=x_0}$$



A more general form that clearly identifies the error term is given by the p^{th} order Taylor series expansion of $f(x)$ with $\tilde{x} \in [x, x + \Delta x]$

$$f(x + \Delta x) = \sum_{n=0}^p \frac{(\Delta x)^n}{n!} \left. \frac{d^n}{dx^n} f(x) \right|_{x=x} + \frac{(\Delta x)^{p+1}}{(p+1)!} \left. \frac{d^{p+1}}{dx^{p+1}} f(\tilde{x}) \right|_{x=x}$$

Brook Taylor (1685 – 1731): English mathematician

Got questions?

If you do, find a way to contact me; and do so sooner than later

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