Beyond the Mouse – A Short Course on Programming

1. Thinking programs

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Geophysical Institute, University of Alaska Fairbanks

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YOU'LL NEVER FIND A PROGRAMMING LANGUAGE THAT FREES YOU FROM THE BURDEN OF CLARIFYING YOUR IDEAS.
BUT I KNOW WHAT I MEAN!

"The Uncomfortable Truths Well",
http://xkcd.com/568 (April 13, 2009)

Outline

1. Overview and Philosophies

2. Thinking programs

3. Building programs

4. Summary

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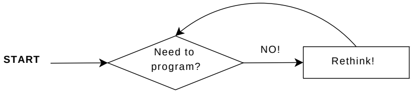
The Program . . .



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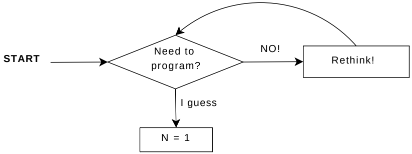

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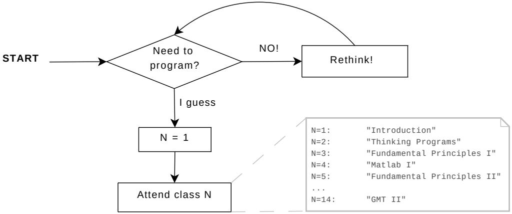

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N=14:      "GMT II"
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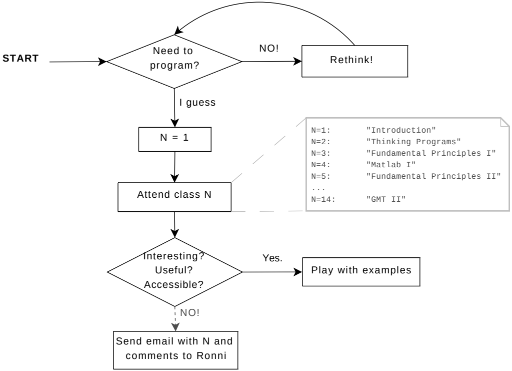

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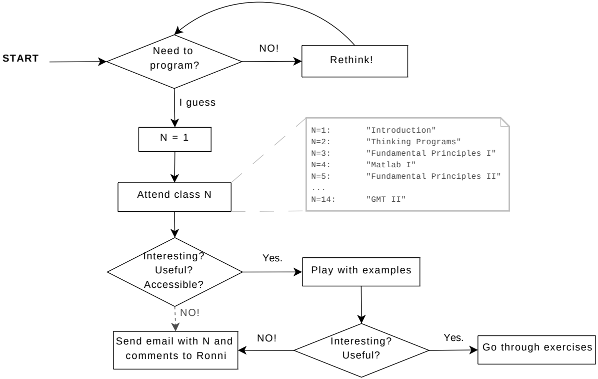

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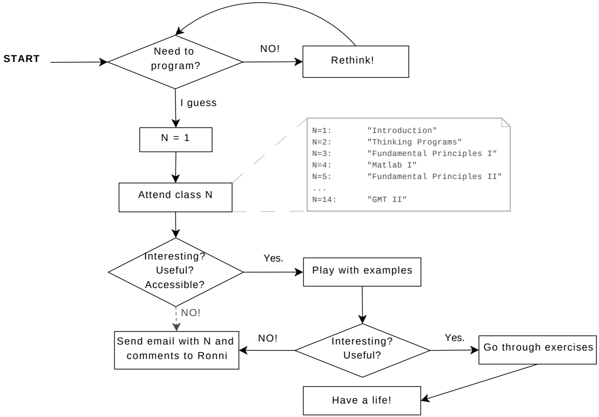

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Need to program?

NO!

Rethink!

I guess

N = 1

Attend class N

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Interesting?
Useful?
Accessible?

Yes.

Play with examples

NO!

Send email with N and comments to Ronni

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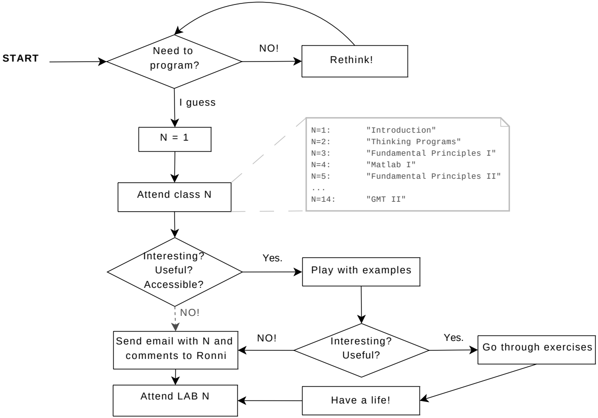
Interesting?
Useful?

Yes.

Go through exercises

Have a life!

The Program . . .



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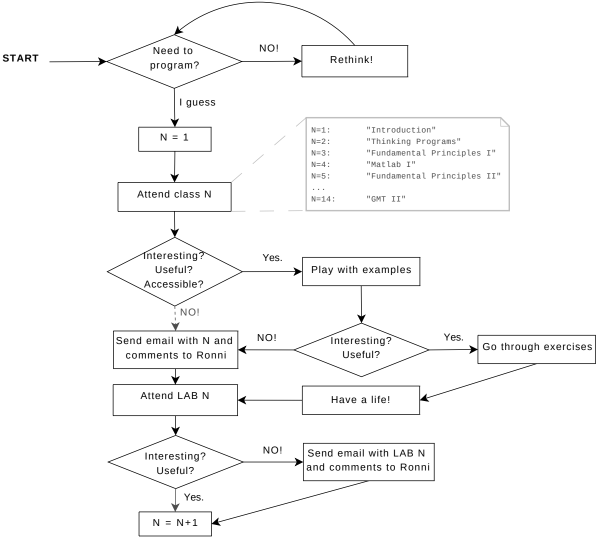

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N = N+1

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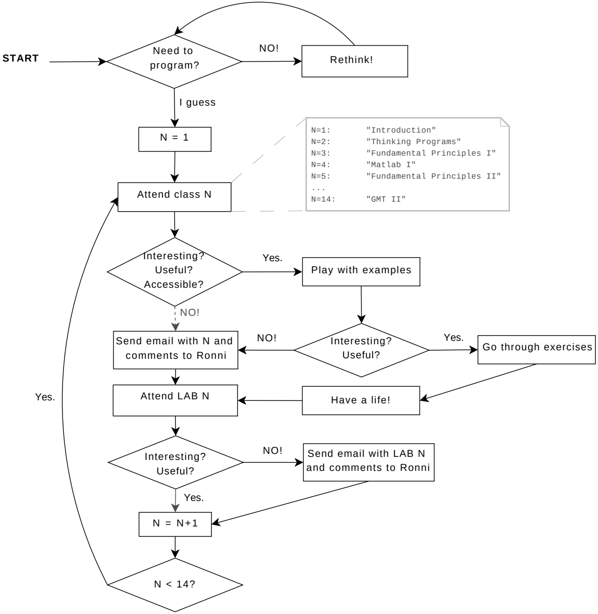

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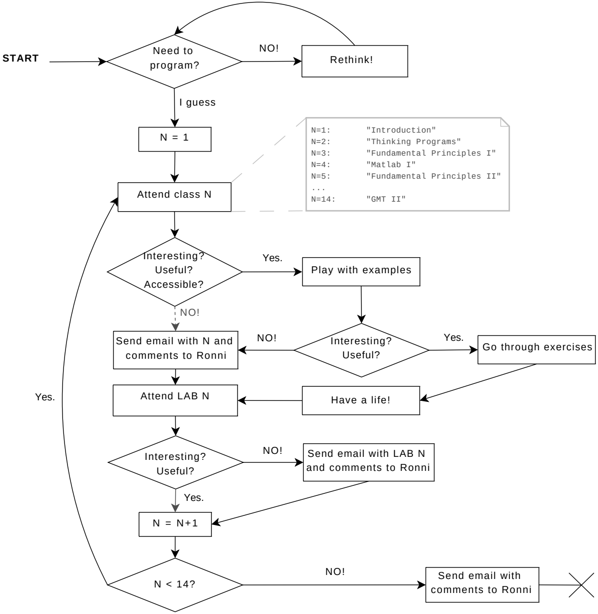
N = N+1

N < 14?

The Program . . .



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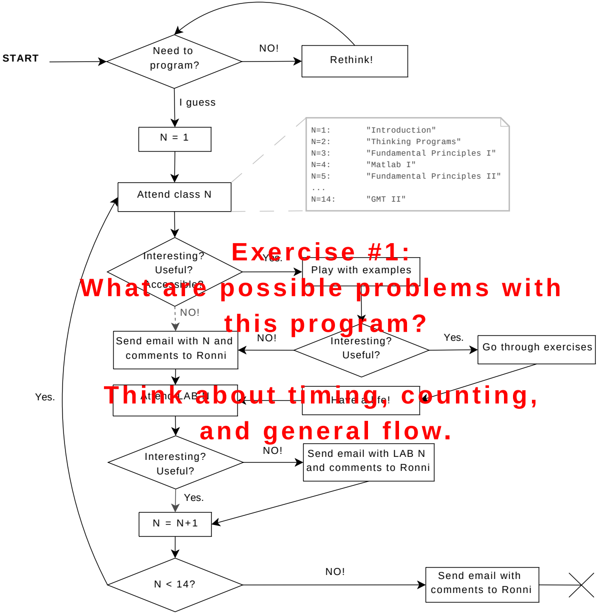

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Exercise #1:

What are possible problems with this program?

Think about timing, counting, and general flow.

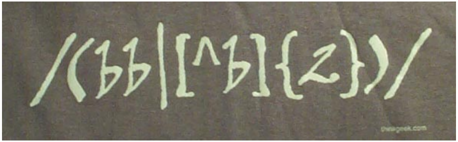
The very basics (1)

From ‘The Conscience of a Hacker’, The Mentor (1986):

[. . .] I made a discovery today. **I found a computer.** Wait a second, this is cool. It does what I want it to. **If it makes a mistake, it’s because I screwed it up. Not because it doesn’t like me . . .**
Or feels threatened by me . . .
Or thinks I’m a smart ass . . .
Or doesn’t like teaching and shouldn’t be here [. . .]

The very basics (2)

- Programming is beyond language.



http://thinkgeek.com

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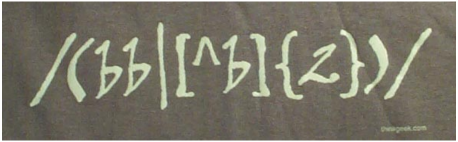

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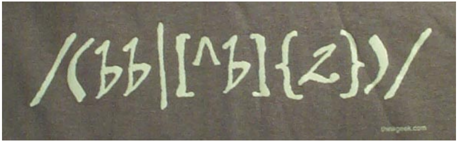

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“When I’m writing poetry, it feels like the center of my thinking is in a particular place, and when I’m writing code the center of my thinking feels in the same kind of place.”

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- Programming is beyond language.
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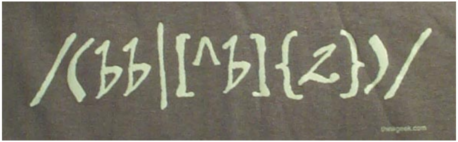
- RTFM *and/or* the internet



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More Philosophy . . .

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Implications . . .

- publications should include data and code (example: Okada)
- figures should be reproducible by readers
- write code that others can use!

What does that mean?

Good

```
function fp = screw2d(x, xf, d, sdot)
% function fp = screw2d(x, xf, d, sdot)
%
% Computes fault-parallel slip rate for 2D screw dislocation
% with fault located at xf, with locking depth d and slip rate sdot.
% Will compute at one or many locations x.
%
% x     column vector
% xf    scalar
% d     scalar
% sdot  scalar
%
if ( d == 0 )
    fp = sdot*0.5*sign(x-xf*ones(size(x)));
else
    fp = sdot*atan2((x-xf*ones(size(x))),d)/pi;
end
```

What does that mean?

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Bad

```
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if(d==0)fp=sdot*0.5*sign(x-xf*ones(size(x)));else fp=sdot*atan2((x-xf*ones(size(x))),d)/pi;
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Thinking programs – Breaking down complex tasks

Example 1:

Getting into grad school ... and out.

Thinking programs – Breaking down complex tasks

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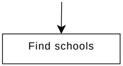
Getting into grad school ... and out.

things to do:

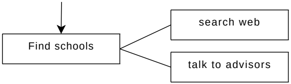
apply, figure out where to go, visa stuff, class work, research, thesis ...

Thinking programs – Breaking down complex tasks



Find schools

Thinking programs – Breaking down complex tasks



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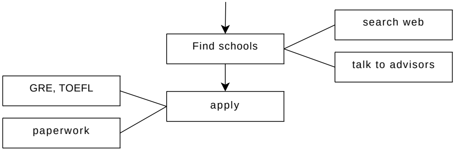


Find schools

search web

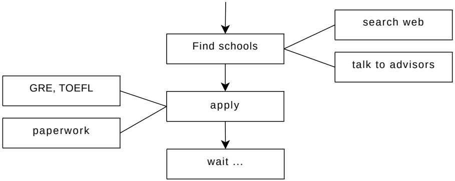
talk to advisors

apply

GRE, TOEFL

paperwork

Thinking programs – Breaking down complex tasks



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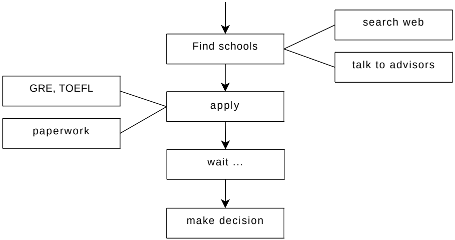

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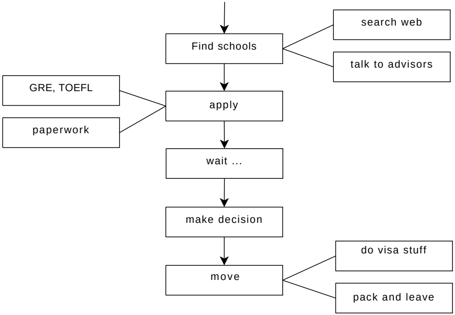

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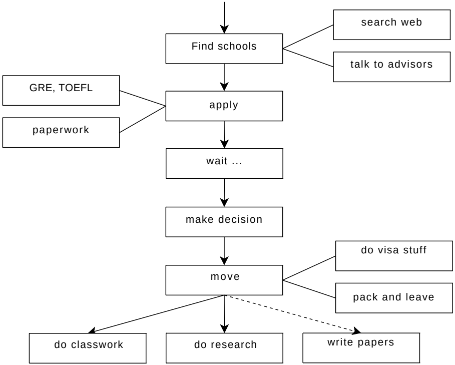

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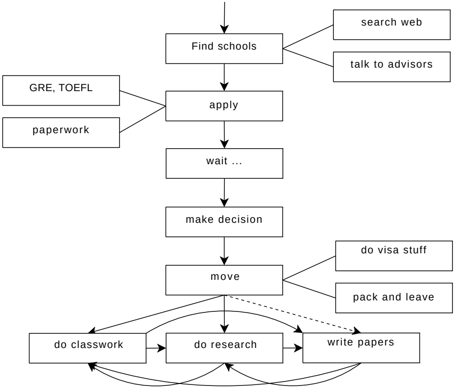

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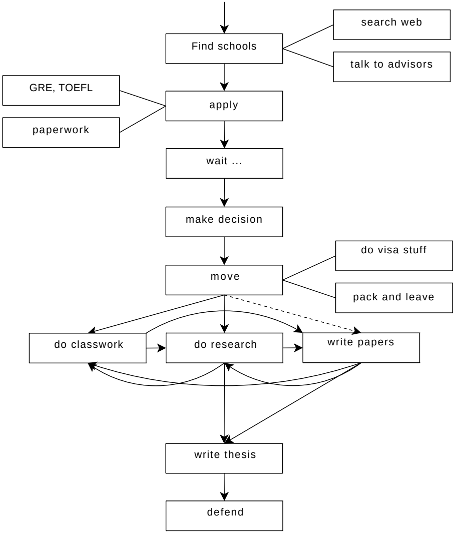

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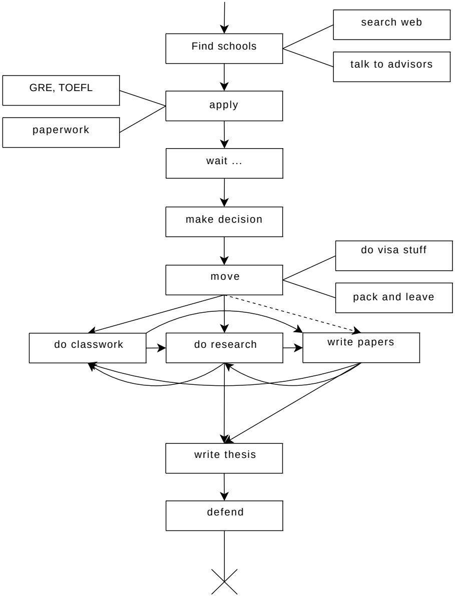

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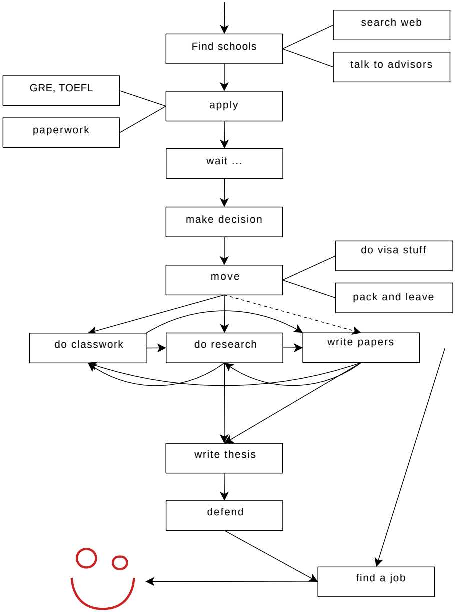

Thinking programs – Breaking down complex tasks

Example 2:

Grad student’s Average Day

Thinking programs – Breaking down complex tasks

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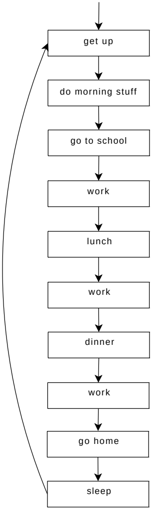
Grad student’s Average Day

possible activities:

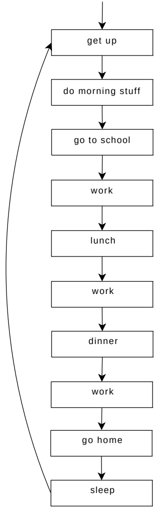
eat, sleep, work, do stuff, . . .

Thinking programs – Breaking down complex tasks



Listing 1: make_my_day

Thinking programs – Breaking down complex tasks



get up

do morning stuff

go to school

work

lunch

work

dinner

work

go home

sleep

possible implementation

```
% make_my_day.m
%--------------------
% program that shows how much fun
% live as a grad student is :)

clc;

getUp;
eat('breakfast');
walk('school');
work;
eat('lunch');
work();
eat('dinner');
work();
walk('home');
haveLife;
sleep;
```

Listing 1: make_my_day

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Building programs – One black box at a time

Strategies to implement a program:

Top down

Same as the examples above:

- start with the big picture
- identify reasonable subtasks
- try to divide things to a level of managable complexity (atoms)
- implement atoms
- implement main routine (flow control)

Building programs – One black box at a time

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Top down

Same as the examples above:

- start with the big picture
- identify reasonable subtasks
- try to divide things to a level of managable complexity (atoms)
- implement atoms
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Bottom up

- problems accumulate
- implement an atom at the time
- at some point you figure out that things could go together
- revise main routine constantly
- add necessary subroutines

Building programs – One black box at a time

Bottom line

- Try building tools that solve a set of similar problems in a generic way. Use Parameters!
- Build and test each atom individually, test all scenarios (and more) with synthetic input.
- Treat atoms as black boxes that implement desired functionality. Don't care about them once they're working

Building programs – One black box at a time

Keys to good programs

- **Modularity**: split problem in manageable tasks, implement and test one at a time

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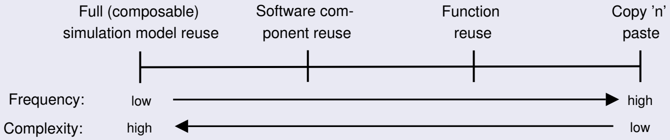

Pidd, 2002

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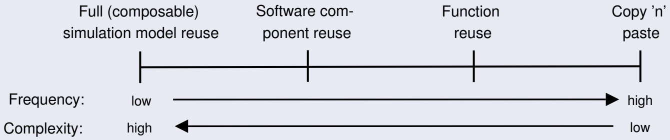

Pidd, 2002

- **Generalize**: use variables instead of hard coded values, hand parameters to functions

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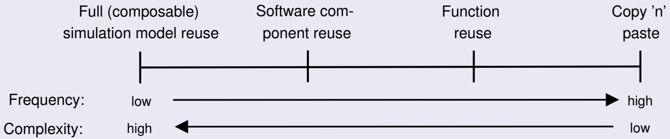

Full (composable) simulation model reuse

Software component reuse

Function reuse

Copy 'n' paste

Frequency: low → high

Complexity: high ← low

Pidd, 2002

- **Generalize**: use variables instead of hard coded values, hand parameters to functions
- Functionality, then efficiency

Building programs

The Control Routine

```
% make_my_day.m
%——————————————
% program that shows how much fun
% live as a grad student is :)

clc;

getUp;
eat('breakfast');
walk('school');
work;
eat('lunch');
work();
eat('dinner');
work();
walk('home');
haveLife;
sleep;
```

Using Parameters

```
% eat.m
%——————————————
function eat(what)
    fprintf(1,'%s:␣yummy␣...␣%s\n', ...
        mfilename, what);
    pause(1);
end
```

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Summary – Take home messages

Thinking . . .

- Think modular
- Think in general cases
- Think non-redundant
- Think about reuse
- Think about reproducibility

Exercising . . .

- Read other peoples' code . . . critically
- The first version is for the trash bin (unintentionally)

Summary – Take home messages

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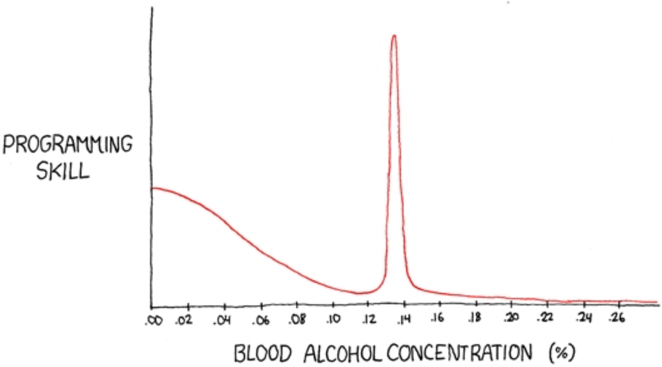
Truth . . .

Your working environment will change, concepts likely survive! Be flexible in the choice of languages and tools.

If all fails . . .



“The Ballmer Peak”

http://www.xkcd.com/323/