Information Science
1: Guidance

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Integrated Course: "Information Science"

Lecturer: Naonori Kakimura (垣村 尚徳)

Date: Mon.5 (16:50-18:35)

Room: E41(Information Bldg. 4F)

- No Food or Drinks in this building
- Do not use the elevator, and use the staircase

➢ My contact information

- Mail: kakimura@global.c.u-tokyo.ac.jp
- No office hour (appointment is needed)
- Questions are welcome before and after the class

Today's Contents

Guidance + simple exercises of Ruby

➢ Guidance for this course
- ❑ DO NOT switch your terminal on yet

- ● Objectives and plan
- ● Class style and evaluation

➢ Exercises using "irb"
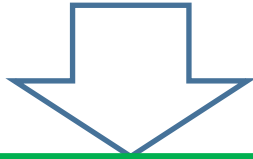- ● Calculation
- ● Math function
- ● Variables

Road Map on Information-Related Courses

for PEAK students

1st

Information
(required for JEA & ES)

Academic topics
as a literacy

3rd

Information Sciences
(elective, integrated F)

More science-oriented topics

(mandatory for students enrolled in 2012)

Road Map on Information-Related Courses

for PEAK students

1st

Information
(required for JEA & ES)

3rd

Information Sciences
(elective, integrated F)

Studying basic information science

through Ruby programming

easy-to-use language
similar to Perl or Python

- discrete mathematics
- modeling
- data structure
- theory of algorithms
- scientific computation

fundamental concepts
for "information" in various fields

(independent of studying program. langs)

How to formulate real-world problems
    solve them using computers

4th semester   **(mandatory)**

Necessary theory

Numerical simulation methods

- Difference equation
- Mathematical modelling
- Applied linear algebra

You can use *any* programming language

Programming may be required

- Programming may increase what you can do in every area (e.g., statistics, data analysis of experiments..)
- Better to learn programming somewhere

Cf) Senior Division: Toward Applications

How to formulate real-world problems
solve them using computers

4th semester **(mandatory)**

> ## Numerical simulation methods

6th/8th (elective)

> ## Operations Research

8th/6th (elective)

> ## Environmental Informatics
> by Prof. Fukunaga

Necessary theory
- Difference equation
- Mathematical modelling
- Applied linear algebra
- Optimization methods

Applications
- Operations research
- Network analysis
- Environmental problems
- Urban engineering
- Ecology, etc.

What is "Information Science"?

➢ Science base related to information
- ●"information" is getting important in various fields
  - ☐Analysis using huge amount of data

- ●Combination of other fields
  - ☐Bioinformatics (relation to biology)
  - ☐Chemo-informatics (chemistry)
  - ☐Geoinformatics (geographical information)
  - ☐Environmental informatics
  - ☐Health informatics
  - ☐. . .

Main Purpose

➢ Study basic concepts of information science

- Introduction to computer science
  - □ Useful in various fields
- More theoretical than previous course "information"

➢ Remark

- □ not to make a commercial program
- □ more primitive, rather academic-related fields
  - Out of scope
    - o Make a cool application/web page
    - o Make an exciting game
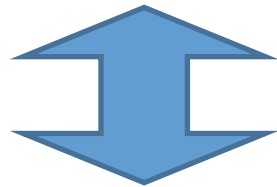- you may be able to apply your obtained skill in future
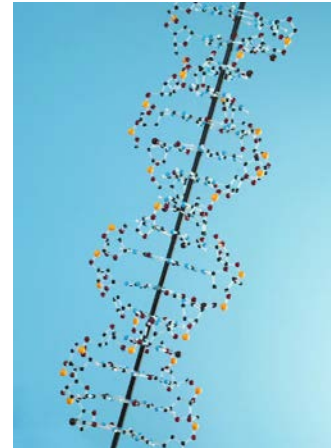
Example in Bioinformatics

➢ How can we solve the following?
  - Detect a similarity between DNA sequences

DNA

Human being : ATGCATGCATGCATC…

Monkey: ATGCTTGATGCATCG…

How to define "similarity"?
How to compute the "similarity" quickly?

Example: with Different Application

➢ Error correction of Google = similarity detection

Other Examples

➢ How can we solve the following?
- Detect similarity between two sentences
  - ❑ applications in DNA analysis and Google
- Simulation of ecosystems
- Web search engine(Google)
  - ❑ display the most related webpages to a keyword
    - = Order elements with respect to their scores

- Problem like a puzzle: Tower of Hanoi
- Scientific computation (computing math formulae)
  - ❑ Find a solution of quadratic equations
  - ❑ Solve system of linear equations $Ax = b$ (Next semester)
  - ❑ Compute an integral or a differential (Next semester)

$$\int_0^1 x^2 dx \qquad\qquad \frac{\mathrm{d}x^3}{\mathrm{d}x}$$

Class Style

➢ Lecture (about 40min) + Exercises(rest)
- Some exercises are required to submit
- A little explanation and a lot of exercises

➢ Lecture materials are uploaded at ITC-LMS
- ITC-LMS: Learning management system
  - https://itc-lms.ecc.u-tokyo.ac.jp/portal/login
- Webpages:
  - http://www.graco.c.u-tokyo.ac.jp/~kakimura/teaching.html
  - Google "kakimura" -> teaching

About Exercises: Using Ruby Language

➢ Programming to learn concepts in info science
- Programming skill is not the final goal
  - But good to learn it for your future research
- Easy to do trial&error: advantage of info science
- Useful when studying other programming languages

➢ Ruby
- easy-to-use language similar to Python or Perl
  - introduction to other advanced languages(C, Java)
  - Used in large-size system (Rakuten, Twitter)
- We use "irb": interactive Ruby
- Made in Japan

1st Half : Basic Programming Skills

➤ numbers, calculation, and functions
  - variables and arrays

➤ conditional processing(IF) & repetition (WHILE)
  - branching, logic operation, string of letters, repetition

➤ from functions to "computation"
  - iterative computation, recursive computation

2nd Half : Fundamental Concepts in Info Science

➢ algorithms and computational complexity
- Fibonacci number
- Sorting algorithm
  - ☐ Knapsack problem

➢ pattern recognition
- Pattern matching of strings
- Similarity of two strings

➢ Simulation (a bit)
- Random numbers

Tentative Plan (13 Sessions in total)

- [9/26 Today] Guidance＋How to use Ruby 1
- [10/ 3] How to use Ruby 2: Functions
  - [10/10] No class
- [10/17] If, while, and for
- [10/24] Arrays
- [10/31] Making an image with arrays
  - Home assignment
- [11/7, 11/14] Iterations and Recursions
- [11/21, 12/5, 12] Algorithms and complexity
  - [11/28] No class
  - Bisection methods, Fibonacci number, Sorting
- [12/19, 26] A string of characters and Alignment
  - Dynamic programming
- [1/7] Simulation

Evaluation (tentative plan): **110 in total**

➤ Quizzes during sessions (about 40%)
- Raw score will be put in your grades
- Including Attendance/Lateness

➤ 2(or 1) big home assignments (about 20%)
- Depending on the number of assignments

➤ Final Exam (about 50%) (Jan. 23 Mon. P5?)
- *Written* exam similarly to April-entry students
- No PCs or no calculator will be allowed

Quizzes during Sessions

➢ Required to submit

- I will give marking
- The deadline is by the next week
  - Today's one should be submitted by today
  ❑To have time to do at home
  ❑To have time to ask during the next session

  (if necessary)

Reference (Textbook in Japanese)

➢ 「情報科学入門」 (じょうほう かがく にゅうもん)
  ❑ meaning "introduction to information science"
  ● 増原英彦＋東京大学情報教育連絡会 編
  ● 東京大学出版会 Univ. Tokyo Press

➢ The lecture basically follows the book
  ● But no need to buy/read
  ● Slides contain almost topics
  ● We also have original materials not in the textbook

Other References on Ruby

➢ Some books are available (ask me)

- D. Flanagan, Y. Matsumoto, The Ruby Programming Language, O'Reilly, 2008.
  - ❑ Detailed introduction to Ruby
- C. Pine, Learn to Program (The Facets of Ruby Series), Pragmatic Bookshelf, 2009.
  - ❑ more gentle introduction to Ruby

➢ A lot of free tutorials on the Internet

- Ruby programming and information science

➢ Encourage you to study on your own

- If you need a book not in Library, please ask me
  - ❑ I can buy and lend you if it is useful for us

Introduction to Ruby

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➢ Exercises using "irb"
- Calculation
- Math function
- Variables

Objective of Today's Exercises

➢ Getting used to Ruby

- "irb": Interactive Ruby
  - Can put Ruby commands in an interactive way
    - Easy to make a program
    - Similar interface to the programming lang R
  - You can install it to your computer
    - https://www.ruby-lang.org/ja/
    - A PDF file on ITC-LMS

➢ Playing with irb following instructions of Slides

Remarks on ECCS

➤ ECCS system has been updated on Apr 2016.
- Your files are probably alive
- OS has been updated

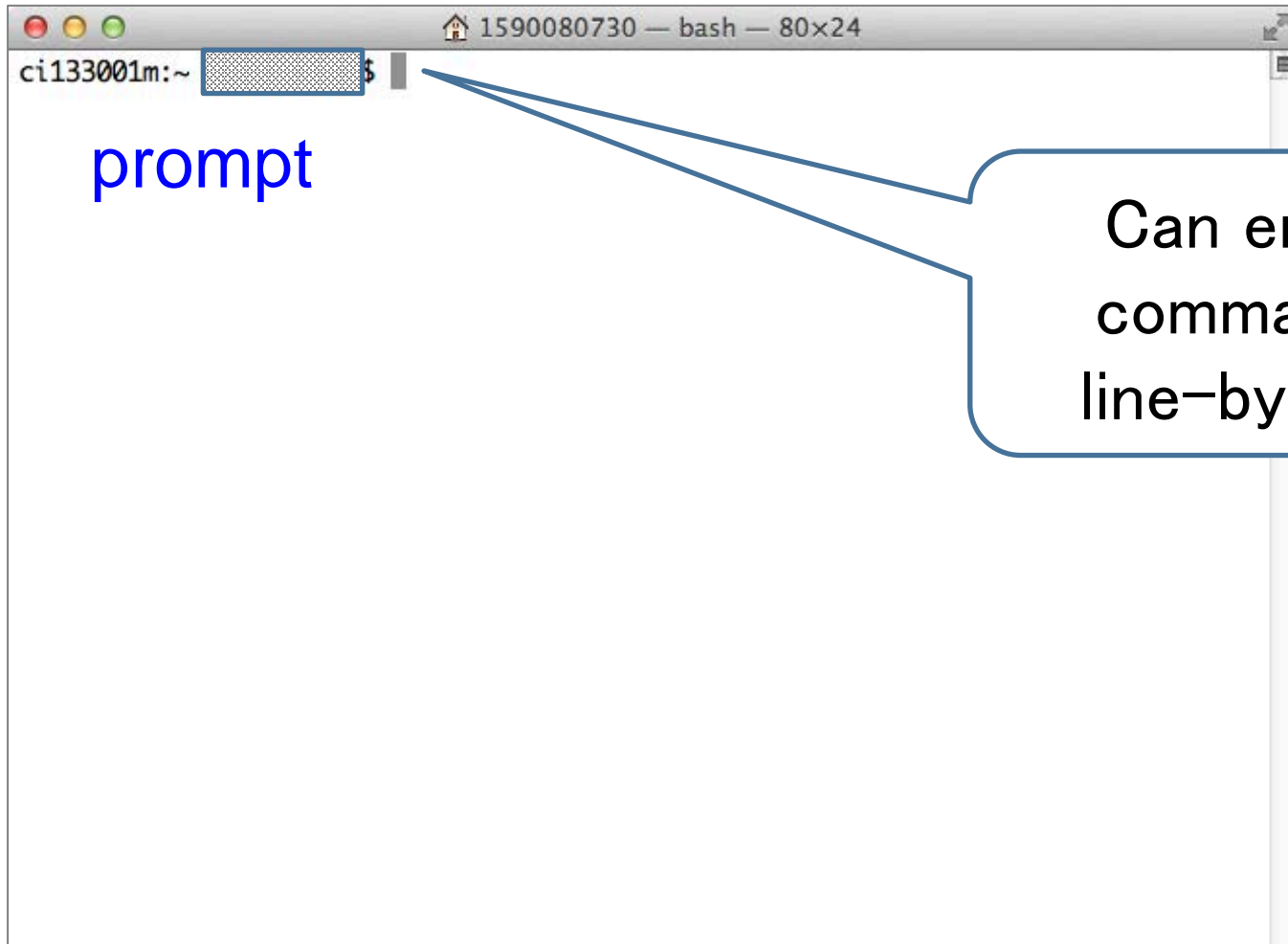➤ Tell me if you have any trouble

Steps to start up "irb"

➤ Step 0. Log in to Mac

➤ Step 1. Run a command terminal

➤ Step 2. Type "irb" (and return) on the terminal

Step 1. Run a Command Terminal

➢ Click on [terminal icon] in the Dock

Interface based on keyboard typing

```
● ○ ○                🏠 1590080730 — bash — 80×24
ci133001m:~ ▒▒▒▒▒▒▒ $ |
```

prompt

Can enter commands line-by-line

Step 2. Run irb

➢ Type "irb" and press the Return key

cm12345$ irb

Red characters in slides
= typing sentences

Prompt of the
terminal

Prompt of "irb" Appears

➢ Prompt becomes different

● You can check whether "irb" is running or not

cm12345$ irb
irb(main):001:0>
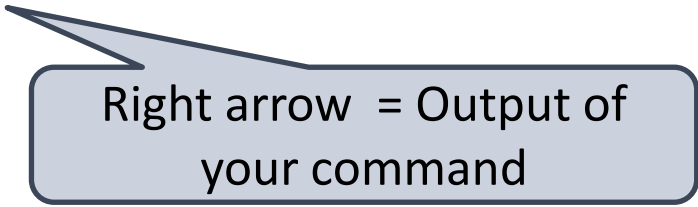
Prompt of irb

You can enter some math expressions

cm12345$ irb

irb(main):001:0> 1+1 (Return)

=> 2

Right arrow = Output of your command

First Program

➢ You allow Ruby to say something

cm12345$ irb
irb(main):001:0> 1+1 (Return)
=> 2
irb(main):001:0> print "Hello"
Hello => nil

> Printed "Hello", but the output is "nothing"

irb(main):001:0> print "Hello＼n"
Hello
=> nil

> "＼n"(or "¥n" in Windows)
> means the line break

To exit from "irb"

➢ Type "exit" "quit" or press Ctrl + D

      cm12345$ irb

      irb(main):001:0> 1+1 (Return)

      => 2

      irb(main):002:0> Ctrl + D

      press D holding Ctrl-key

      cm12345$

> Equivalently, typing in "exit" or "quit"

➢ Let's play with irb today

● Better to type in commands *by hand not by copy*

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- ● Variables

You can calculate --- like a calculator

irb(main):003:0> 7 – 2

=> 5

Subtraction

Always need to press Return key

rb(main):004:0> 7 * 2

=> 14

Multiplication

irb(main):005:0> 7 / 2

=> 3

Division (Quotient)

It's OK to have a blank

You can calculate --- like a calculator

irb(main):006:0> 7 % 2

=> 1   Remainder of 7 when divided by 2

irb(main):007:0> 7 ** 2   Not "* *"

=> 49   7 to the power of 2

➢ Do the following on your terminal

- Guess the answer before using Ruby

(a) 3+2*4

(b) 4/2*2

(c) 4/(2*2)

(d) 4/2**2

(e) (3+2)*(5-1)

- also try (3+2)(5-1) (resulting in an error)

When You Are Lost (or Confused)

➢ Press Ctrl C during the process in any case
- Force-quit and back to the top level of irb

Rem. Priority of Math Operations

➢ Basically same as math
- Left association .. a ◯ b ◯ c = (a ◯ b) ◯ c
- Right association .. a ◯ b ◯ c = a ◯ (b ◯ c)

➢ Ordering: Same as Math
① monomial (right association)
② *, /, % (left association)
③ +, − (left association)
④ = assignment

➢ Use ( ) to change the order
➢ Cannot omit * of (x+y)*(s+t)

1. Which is not "56 to the power of 16"?

1. 56 ** 16
2. (7 * 8) ** 16
3. 7 * 8 ** 16
4. 56 ** 4 ** 2
5. 56 ** (4 ** 2)

※ Submit it from LMS later

➤ Ruby distinguishes integers and real numbers

irb(main):012:0> 7 / 2
=> 3
irb(main):012:0> 7.0 / 2
=> 3.5
irb(main):013:0> 7 / 2.0
=> 3.5

Calculating integers -> output is an integer
reals   -> output is a real

2. What is "17 - 17/3*3"? (and Consider Why)

1. 0.0
2. 0
3. 2
4. 15.1111111111111
5. 16

※ Submit it from LMS later

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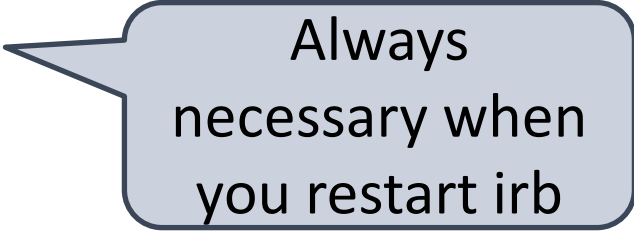- Calculation
- Math function
- Variables

Preparing Mathematical Functions

irb(main):003:0> include(Math)
=> Object

Always necessary when you restart irb

Mathematical Functions

irb(main):003:0> include(Math)
=> Object
irb(main):004:0> sqrt(2)   **Sq**uare **r**oo**t**
=> 1.41421356 23731
irb(main):005:0> cos(3.141592/3)   a trig function
=> 0.50000018867511
irb(main):005:0> PI
=> 3.141592653589793
irb(main):005:0> cos(PI/3)
=> 0.5

Slightly different from cos(π/3)=1/2

π is already defined

Mathematical Functions

irb(main):004:0> exp(2)   e to the power of 2

=> 7.38905609893065

irb(main):005:0> log(10)   Log Base e

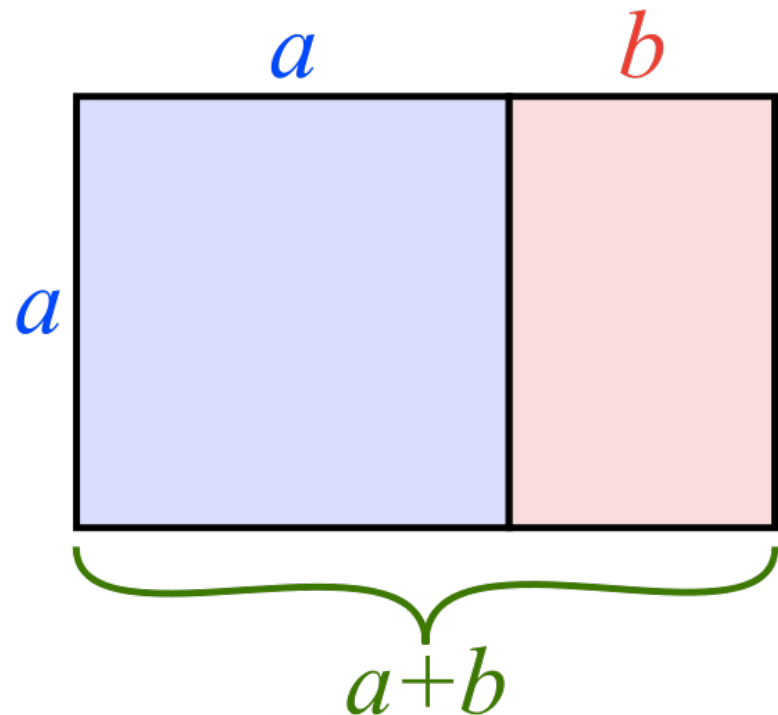=> 2.302585092994046

irb(main):005:0> log10(10)   Base 10

=> 1.0

Rem. No "log3" etc.
Only log and log10 are prepared
in Ruby

3. What is the Golden Ratio?

➢ You have a rectangle with longer side a and shorter side b

➢ When we place a square with sides of length a adjacent to the rectangle, we have a similar rectangle (the ratio of both sides is a/b)
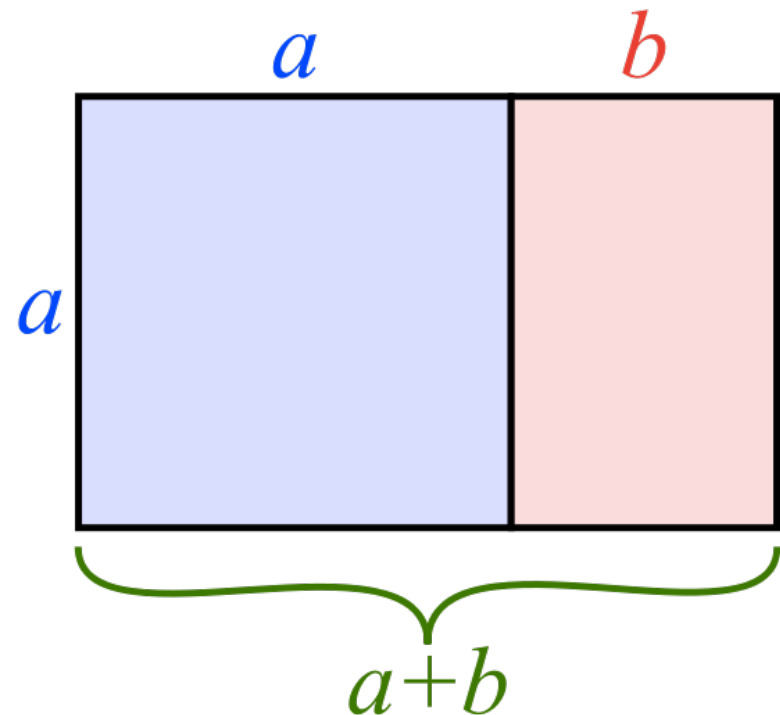
What is a/b?
Choose one from
the next slide

a b

a

$a+b$

3. What is the Golden Ratio?

1. 1.61803398874989
2. 1.61803398874988
3. 1.61803398874987
4. 1.61803398874986
5. 1.61803398874985

※ Submit it from LMS

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- ● Variables

Variables --- Giving a name to a value

Container having a value

Assign the value 10 to the variable a

irb(main):003:0> a=10
=> 10

Assigned value is displayed

irb(main):004:0> a
=> 10

irb(main):006:0> a+10
=> 20

Variables can be used in calculation

Variables --- Giving a name to a value

Container having a value

Assign the value 188.0 to the variable h

irb(main):003:0> h=188.0
=> 188.0
irb(main):004:0> w=104.0
=> 104.0

Can do complicated calculation

irb(main):006:0> w / (h /100.0) ** 2
=> 29.4250792213671

Variables can be used in calculation

Why do We Use Variables?

➢ Easier to understand the meaning of expressions

w

weight

body_weight_in_pound

➢ Easier to compute it with different values

irb(main):008:0> w=104.0-10

=> 94.0

irb(main):009:0> w / (h/100.0) ** 2

=> 26.5957446808511

> OK to write
> w=w-10

> Same
> expression

Remarks on Variables

➢ small letters & CAPITAL letters are distinguished
  - Ex. Different: SUM, Sum, and sum

➢ We cannot use special characters such as &, %, but can use "_"
  - NG: sum of scores
  - OK: sum_of_scores
  - OK: ScoreSum

4. Exercises: Use Variables in irb

➢ Set x = 10, y = x(x − 3), z = y(y − 3).

➢ Then compute z(x − 3).

※ Do not forget inserting * when multiplying

※ Submit this from LMS

Optional Exercises: (No Need to Submit)

➤ Assign the golden ratio to variable g
➤ Confirm that (1+g)/g is equal to g

     ❑ Check that (1+g)/g – g is equal to 0

irb(main):006:0> (1+g)/g - g
=> 0.0

Summary So Far

➤ Include(Math)
- Command necessary to use Math functions

➤ Variables
- "Name of vars" = Value
  - assign the value to the variable on the left-hand side

Today's Quiz and Next Week

➢ Solve quizzes on LMS by Today
  - Exercises on the slides

➢ Next Week(Oct 3)
  - Using Functions

➢ We have appendix about Commands
  - See also
    ☐ How2Install.pdf
    ☐ Commands.pdf
    ☐ Tips.pdf

Appendix: Errors

```
irb(main):001:0> 3/0
ZeroDivisionError: divided by 0
        from (irb):1:in `/'
        from (irb):1
irb(main):002:0> 7 - 2 3
SyntaxError: compile error
(irb):2: syntax error, unexpected tINTEGER, expecting
  $end
        from (irb):2
irb(main):003:0> (7 -
irb(main):004:1* 2) * 3)
SyntaxError: compile error
(irb):4: syntax error, unexpected ')', expecting $end
        from (irb):4
irb(main):005:0>
```
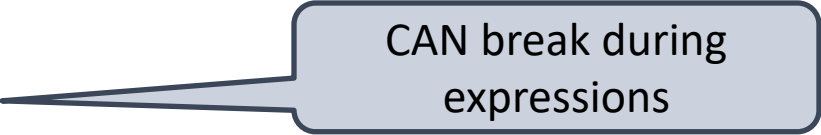
CAN break during expressions

Appendix: Errors

irb(main):013:0> bm1(188.0, 104.0)

NoMethodError: undefined method 'bm1' for main:

Object

from (irb):13

Appendix: Useful Commands for irb

➤ Ctrl p or ↑ ↓ : trace back the last inputs
  ● Ctrl n : same as ↓
➤ Ctrl c : force-quit
➤ Ctrl d : quit irb

➤ Tab: complement your typing

➤ Ctrl r : Search the history
➤ Ctrl b or ← : Move the cursor to the left
➤ Ctrl f or → : Move the cursor to the right
➤ Ctrl a: Move the cursor to the beginning
➤ Ctrl e: Move the cursor to the end
➤ Ctrl k: Delete the right part after the cursor
➤ Ctrl w: Delete the left part before the cursor
➤ Ctrl y: Recover deleted one at the position

Appendix: Useful Commands for Terminals

1. pwd （print working directory）
   display the current directory

2. ls （list segments）
   display all files & directories in the current directories

3. mkdir （make directory）
   make a directory

4. mv （move）
   move a specified file to another place,
   rename a specified file (= move it to same place)

5. cd （change directory）
   Change the current directory

6. cp （copy）
   copy a specified file

Appendix: Useful Commands for Terminals

7. rm （remove）
   remove a specified file
8. cat （catenate）
   Display a file
9. du -sm
   confirm your disk usage