

# Algorithms for Programming Contests - Week 1

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# General Concept

- Theoretical background about several concepts and algorithms.
- Learn and prepare for programming contests, job interviews, algorithmic challenges.
- If interested: Take notes!

# The Problem Sets

- Available on the course homepage, accessible with password only (ask us for it).
- Usually, five problems per week:
  - two easy (4 Points each),
  - two medium (6 Points each),
  - one hard (8 Points).
- Apply algorithms and concepts from the lecture.
- Each week's problems are (mostly) about the topics from that week's lecture.
- There will be hints in the lectures.

## Have a Problem with a Problem?

Should difficulties arise: Ask questions! Come to our offices or write a clarification request!

# Grading

Your final grade will be determined by how many points you earned, as well as an oral exam at the end of the semester. The oral exam will account for 40% of the grade.

The (tentative) key for grading the problems is the following:

Percentage	Grade
$\geq 90\%$	1.0
$\geq 85\%$	1.3
$\geq 80\%$	1.7
$\geq 75\%$	2.0
$\geq 70\%$	2.3
$\geq 65\%$	2.7
$\geq 60\%$	3.0
$\geq 55\%$	3.3
$\geq 50\%$	3.7
$\geq 40\%$	4.0

# Topics

- 1 Introduction
- 2 Data Structures (UF, Binary Search, Graphs)
- 3 Graphs, Minimum Spanning Trees, DFS, BFS
- 4 Shortest Paths
- 5 Maximum Flows
- 6 Brute Force / Backtracking
- 7 Greedy
- 8 Dynamic Programming
- 9 Number Theory
- 10 Trees
- 11 Geometry
- 12 Projective Geometry
- 13 Contest
- 14 Conclusion

# Official DOMjudge System

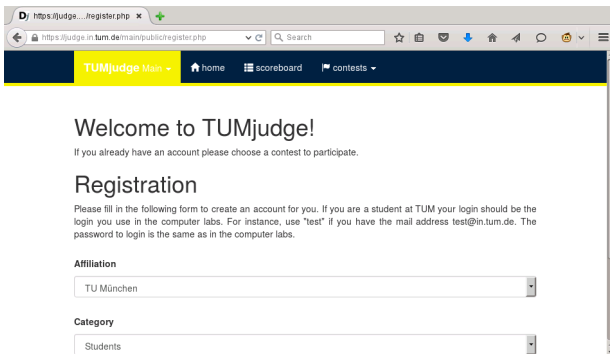
- In use for programming contests such as the GCPC or the ICPC.
- On the web:

TUMjudge

<https://judge.in.tum.de>

# Registration

- Registration necessary.



The screenshot shows a web browser window with the URL `https://judge.in.tum.de/main/public/register.php`. The page has a dark blue header with a yellow bar containing the text "TUMjudge Main". Navigation links for "home", "scoreboard", and "contests" are visible. The main content area features a large heading "Welcome to TUMjudge!" followed by the instruction: "If you already have an account please choose a contest to participate." Below this is a section titled "Registration" with the text: "Please fill in the following form to create an account for you. If you are a student at TUM your login should be the login you use in the computer labs. For instance, use 'test' if you have the mail address test@in.tum.de. The password to login is the same as in the computer labs." The form contains two dropdown menus: "Affiliation" with "TU München" selected, and "Category" with "Students" selected.

**Welcome to TUMjudge!**

If you already have an account please choose a contest to participate.

## Registration

Please fill in the following form to create an account for you. If you are a student at TUM your login should be the login you use in the computer labs. For instance, use "test" if you have the mail address test@in.tum.de. The password to login is the same as in the computer labs.

**Affiliation**

TU München

**Category**

Students

# Login

- Authentication necessary.
- Works with LDAP and is identical with the login to the computer lab (“Rechnerhalle”).
  - Login is “name” in `name@in.tum.de`.
  - Password is the corresponding password.
- Forgot your password and want to change / reset it?
  - Get in contact with the RBG, not with us!



# Overview

The overview page shows several pieces of information:

- the personal scoreboard of the current contest,
- an overview of already submitted programs,
- an overview of clarifications (more on that later on).

# Overview

The screenshot shows a web browser window with the URL `https://judge.in.tum.de/conprateam/`. The page title is "Algorithms for Programming Contests SS2015 - Week 10" and the subtitle is "final standings".

The main content area displays a table of final standings for the team "Stefan Toman" from "TU München". The table has columns for Rank, Team, Score, and five problem categories (A, B, C, D, E). The team is ranked 5th with a score of 8632. They have solved 1/0 problems in categories A, B, and C, and 1/8632 in categories D and E.

Below the standings table, there are two sections: "Submissions" and "Clarifications".

The "Submissions" section includes a file upload area with a "Browse..." button and "No files selected." text, a "problem" dropdown menu, a "language" dropdown menu, and "submit" and "cancel" buttons. Below this is a table of submissions:

time	problem	lang	result
09.07.2015 11:43	E	JAVA	TOO-LATE
08.07.2015 14:18	B	CPP	CORRECT
08.07.2015 11:52	D	CPP	CORRECT
01.07.2015 11:24	E	JAVA	CORRECT

The "Clarifications" section includes a table of clarification requests:

time	from	subject	text
09.07.2015 12:12	Jury All	problem E	Dear students, here is the link to Karl's website for drawing the fractals. ...
02.07.2015 12:41	Jury All	problem E	Dear students, please remember that we are looking forward to get your great ...

Below the clarifications table, there is a "Clarification Requests" section with the text "No clarification requests." and a "request clarification" button.

At the bottom of the page, the footer text reads: "TUMjudge version 5.0.0.0, a fork of DOMjudge version 5.0.1 Imprint / Changelog".

# Problem structure

A problem consists of several parts:

- name, abbreviation, difficulty,
- problem author,
- problem statement,
- input format specification,
- output format specification,
- constraints,
- sample input and output.

## SS15N01A Hello World!

*Author: Stefan Toman*

This is probably the first problem you will solve and it should help you set up and test your system. Solve this problem first to make sure everything is in place.

We would like to introduce you to Lea. You will meet her in many of the problems you will solve. After reading all of them you will know her quite well.

Lea is a very friendly person who likes to say hello to everybody, but she doesn't want to say the same thing to every person she meets. Therefore, she never knows what to say. For greeting Bob it is appropriate to say "Hello Bob!", whereas for greeting Peter it is better to say "Hello Peter!". Help her and tell her which sentence to use.

### Input

The first line of the input contains an integer  $t$ .  $t$  test cases follow.

Each test case consists of a single line containing a name *name*.

### Output

For each test case, print a line containing "Case #*i*: Hello *name*!" where *i* is its number, starting at 1. Each line of the output should end with a line break.

### Constraints

- $1 \leq t \leq 20$ .
- No name will contain whitespaces.
- The names' lengths will be at most 100.

### Sample Data

#### Input

```
2
Bob
Peter
```

#### Output

```
1 Case #1: Hello Bob!
2 Case #2: Hello Peter!
```

# Submitting programs

Submitting program is done on the TUMjudge web interface entirely.

- No files to be sent via e-mail etc.
- Only source code files are uploaded, no .class files or similar.

## Submit

- Choose files to be uploaded by Drag-and-Drop or in the menu “Choose Files”,
- Choose problem,
- Choose language (unless already chosen automatically),
- “submit”,
- F5, F5, F5, F5, . . .

# Submitting programs

Stefan Toman

https://judge.in.tum.de/conprateam/

TUMjudge ConPra

home course scoreboard news help contests toman

## Algorithms for Programming Contests SS2015 - Week 10

final standings

RANK	TEAM	SCORE	A	B	C	D	E
1	Stefan Toman TU München	5 8632	1/0	1/0	1/0	1/8632	1/0

### Submissions

No files selected.

time	problem	lang	result
09.07.2015 11:43	E	JAVA	TOO-LATE
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### Clarifications

time	from	to	subject	text
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02.07.2015 12:41	Jury	All	problem E	Dear students, please remember that we are looking forward to get your great ...

### Clarification Requests

No clarification requests.

TUMjudge version 5.0.0.0, a fork of DOMjudge version 5.0.1 Imprint / Changelog

# Judging

## The TUMjudge

- compiles,
- executes,
- tests

the submission against several test cases. As long as the TUMjudge is working on a submission, the submission's status is "PENDING".

The submission is treated instantaneously and the TUMjudge (usually) announces its verdict within a few moments.

# Judging

The following verdicts can occur:

## CORRECT

The submission successfully solved all the test cases.

## COMPILER-ERROR

The submission could not be compiled. The exact error message can be seen on the submission's detail page.

## NO-OUTPUT

The submission does not produce any output. Be sure to output to "standard out".

# Judging

## TIMELIMIT

The submission runs longer than the maximal allowed time and was terminated.

Possible reasons:

- The submission runs in an endless loop.
- The submission is not efficient enough.

## RUN-ERROR

An error occurred during the submission's execution.

Possible reasons:

- Division by 0.
- Incorrectly addressing memory locations, e.g. `ArrayIndexOutOfBounds`.
- Using more memory than the allowed memory limit.



# Judging

## WRONG-ANSWER

The submission's output is incorrect.

Possible reasons:

- The answer is just wrong.
- The answer does not conform to the output format specification given on the problem set.
- The answer is not exact enough (e.g. with floating point answers with a desired precision).

## TOO-LATE

The program was submitted after the submission deadline. It is stored in the system, but no longer processed.

# Scoreboard

Scoreboard Algorithms for Programming Contests SS2015 - Week 10

final standings

RANK	TEAM	SCORE	A	B	C	D	E
1	Jens Woehle TU München (1 Win)	26 3405	1/68	1/111	1/126	3/362	3/421
2	Thomas Tangl TU München (5 Wins)	26 5895	1/0	0/0	1/0	3/1114	1/1181
3	Markus Hasenöhrl TU München (3 Wins)	26 7251	1/0	1/0	1/0	9/1242	1/1209
4	Karl Kraus TU München	26 9461	3/0	5/5802	1/5	1/62	1/162
5	Michael Schreier TU München	26 13443	1/0	1/2	13/55	9/1106	1/277
6	Rustem Bekmukhametov TU München	26 15914	3/144	7/229	1/257	3/6218	5/666
7	Philipp Becker Ehmck TU München	26 19329	1/206	1/248	1/289	7/8997	1/609
8	Christian Buttner TU München	26 20531	1/177	5/5500	1/1237	1/5567	1/570
9	Hamidreza Rizeh TU München	26 25240	1/906	1/907	1/900	25/5682	3/997
10	Rob Coekaerts TU München	26 28218	1/564	1/565	1/566	1/5715	1/568
11	Anjum Parvez Ali TU München	26 29879	5/443	2/586	1/585	5/6328	1/585

ws14 Highlight #j Match Case 1 of 13 matches

Different background colors indicate different outcomes:



Problem solved.



Problem solved first.



Incorrect submission(s).



Submission in pending status.



No submissions.

# Scoreboard

Order (tie-breakers):

- 1 number of solved problems,
- 2 score:
  - per problem: (number of incorrect submissions) \* (penalty time) + (time for the first correct submission),
  - penalty time = 600, i.e., 10 hours,
  - e.g. **3/1820** indicates: the problem was solved with 3 submissions, with a total penalty time of 1820.

You can submit any number of times to solve a problem!

Each week's score itself (apart from the number of problem solved) does not change the grading at the end of the semester, it only affects the position in the scoreboard of that week.

# Scoreboard

Anybody who does not want to be seen in the public scoreboard, must choose the invisibility option during the registration (in “Category”).

# Clarifications

- Messages to the system administrators, i.e., the teaching assistants and/or tutors.
- Sent via the “request clarification” form on the overview page.
- Used for questions about the problems or about the system in general.
- Please choose a subject accordingly: either “general” or the specific problem.
- Depending on the actual question, the answer is only visible to the persons who sent the question, or it is published to all users of the system.
- The answer (along with the question) can be seen on the right side on the overview page.

# Clarifications

Stefan Toman

https://judge.in.tum.de/conprateam/

TUMjudge ConPra

home course scoreboard news help contests toman

## Algorithms for Programming Contests SS2015 - Week 10

final standings

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Submissions

Browse... No files selected. problem

language submit cancel

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Clarification Requests

No clarification requests.

request clarification

TUMjudge version 5.0.0.0, a fork of DOMjudge version 5.0.1 Imprint / Changelog

# Restrictions

- Compilation of a submission may take no longer than 30 seconds. After that time, compilation is aborted and the verdict will be a COMPILER-ERROR.
- The maximal allowed size of a source code file is 256 KB. Bigger submissions will not be accepted.
- During the execution of a submissions, up to 8 GB of memory is available. This includes source code, variables, stack, Java VM (up to 0,35 GB),... If a submission tries to address more memory, it will be terminated and the verdict will be a RUN-ERROR.
- It is not allowed to use multi threading. Each submission has only one processor fully at its disposal.

# Restrictions

Tampering with the system in any way will be penalized!  
Do not fool the system!

- Do not open files, input is always in “standard in”.
- Do not address files locally on the system! This is not possible anyways.
- Do not open network connections.
- ...

Furthermore, please keep the number of submissions at an acceptable level as to not unnecessarily slow judging for all participants.



# Java Submission

```
import java.util.Scanner;

public class JavaSubmission {
    public static void main(String[] args) {
        // create scanner object
        Scanner s = new Scanner(System.in);

        // loop over all test cases
        int t = s.nextInt();
        for(int i = 1; i <= t; i++) {

            // read several types of input
            boolean b = s.nextBoolean();
            String st = s.next();

            // output: use the possibility you like more
            System.out.println("Case_" + i + ": " + st);
            System.out.format("Case_%d#: %s\n", i, st);
        }
        s.close();
    }
}
```

# C++ Submission

```
#include <iostream>
#include <stdio.h>

int main() {
    // loop over all test cases
    int t;
    scanf("%d", &t);
    for(int i = 1; i <= t; i++) {

        // read several types of input
        int j;
        std::string s1;
        char s2[101];
        // use the possibility you like more
        std::cin >> j >> s1;
        scanf("%d %100s", &j, s2);
        // output: use the possibility you like more
        std::cout << "Case #" << i << ": " << s1 << std::endl;
        printf("Case # %d: %s %d", i, s2, j);
    }
    return 0;
}
```

# Python Submission

```
import sys

if __name__ == '__main__':
    case_count = int(sys.stdin.readline())
    for case_number in range(1, case_count + 1):
        n, k = map(int, sys.stdin.readline().split())
        print("Case_{0}:_{1}".format(case_number, n + k))
```

# Understanding Problems

- Read the problem statement very carefully.
- Also the constraints, think about special cases:
  - E.g. if there are negative values or 0 allowed, then there is probably a test case for that.
  - E.g. special characters or a space when dealing with strings.
  - ...

# Solving Problems

- Code efficiently.
  - Think about which data types to use.
  - Sometimes arrays might not have to be two- or three-dimensional.
  - Implement algorithms given in the lecture with their amortized running times.
- Look carefully at the input and output specifications and let your program be conform to those!
- Remove all debug messages before submitting.
- Write comments!

# Code from the Internet

- You are allowed to copy code you find on the internet, but you need to cite the correct source, otherwise we will not accept the submission and may apply other penalties.
- Do this by putting a comment in your code stating the url or similar.
- However, we advise you to code on your own as it improves the understanding about the algorithms involved. You probably need this in subsequent problems anyway.

# Half Points

If the judge does not accept your solution but you are sure you solved it correctly, use the “request clarification” option. In your request include:

- the name of the problem (by selecting it in the subject field),
- a verbose description of your approach to solve the problem,
- the time you submitted the solution we should judge.

We will check your submission and award you half the points if there is only a minor flaw in your code.

We might use submissions from half-point requests (anonymised) as realistic examples of subtle problems in the lectures.

# Big Inputs / Outputs

Let's speak about actual contents of the course!



# Big Inputs / Outputs

- Some problems require you to read/write a substantial amount of input/output.
- Even without doing anything else, this can take longer than the allowed time limit when not handled correctly!

Speed up your code easily!

Use the faster readers / writers when handling big data.

# Java - Input

Always remember to throw `IOExceptions`!

## BufferedReader

```
InputStreamReader r = new InputStreamReader(System.in);
BufferedReader in = new BufferedReader(r);
String line = in.readLine();
String[] parts = line.split(" ");
int n = Integer.parseInt(parts[0]);
double d = Double.parseDouble(parts[1]);
```

## Scanner

```
Scanner s = new Scanner(System.in);
int n = s.nextInt();
double d = s.nextDouble();
```

# Java - Input

Scanner is much more convenient to use but slower!

Input Size	Scanner	BufferedReader
5 Mio Integers	3321 ms	431 ms
50 Mio Integers	30988 ms	3937 ms

# C++ - Input

## cin

```
#include <iostream.h>
...
int n;
double d;
cin >> n >> d;
```

## scanf

```
int n;
double d;
scanf("%d %i", &n, &d);
```

# C++ - Input

Input Size	cin	scanf
5 Mio Integers	1887 ms	552 ms
50 Mio Integers	18789 ms	5467 ms

cin synchronizes with stdio buffers.

Turning this off can make it even faster than scanf.

```
std::ios_base::sync_with_stdio(false);
```

# Java - Output

Assume that we want to print the integer answer  $x$  and the case header for case  $i$ .

## println

```
System.out.println("Case #" + i + ": " + x);
```

## println

```
System.out.format("Case #%d: %d\n", i, x);
```

## BufferedWriter

```
OutputStreamWriter s = new OutputStreamWriter(System.out);  
BufferedWriter out = new BufferedWriter(s);  
out.write("Case #" + i + ": " + x + "\n");
```

# Java - Output

## StringBuilder (println)

```
StringBuilder sb = new StringBuilder();
sb.append("Case #");
sb.append(i);
sb.append(": ");
sb.append(x);
sb.append("\n");
System.out.println(sb);
```

# Java - Output

## StringBuilder (BufferedWriter)

```
StringBuilder sb = new StringBuilder();
sb.append("Case #");
sb.append(i);
sb.append(": ");
sb.append(x);
sb.append("\n");
OutputStreamWriter s = new OutputStreamWriter(System.out);
BufferedWriter out = new BufferedWriter(s);
out.write(sb);
```



# Java - Output

Choose a method that is convenient and matches the expected size of the output.

Output size	println	format	BufferedWriter
5 Mio Integers	27220 ms	37250 ms	558 ms
50 Mio Integers	-	-	5057 ms

Output Size	StringBuilder(println)	StringBuilder (BufferedWriter)
5 Mio Integers	440 ms	470 ms
50 Mio Integers	4057 ms	4234 ms

# C++ - Output

## cout

```
#include <iostream.h>
...
cout << "Case #" << i << ": " << x << endl;
```

## printf

```
printf("Case #%d: %i\n", i, x);
```

# C++ - Output

Output Size	cout	printf
5 Mio Integers	11927 ms	492 ms
50 Mio Integers	-	4919 ms

Again, cout can be improved by using the following line.

```
std::ios_base::sync_with_stdio(false);
```