Data Structures and Algorithms in Java

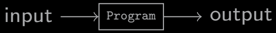
Procedural Programming: Input and Output

Outline

1. Input and Output
2. Standard Output Revisted
3. Standard Input
4. Redirection Operators

Input and Output

Input and Output



input

Program

output

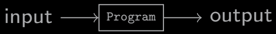
Input and Output

input
Program
output

Input types

- Command-line input
- Standard input
- File input

Input and Output



input → Program → output

Input types

- Command-line input
- Standard input
- File input

Output types

- Standard output
- File output

Standard Output Revisted

Standard Output Revisted

`stdlib.StdOut`

`static void println(Object x)`	prints an object and a newline to standard output
`static void print(Object x)`	prints an object to standard output
`static void printf(String fmt, Object... args)`	prints `args` to standard output using the format string `fmt`

Standard Output Revisted · Formatted Printing

Standard Output Revisted · Formatted Printing

Example

```
StdOut.printf("The value of %s is approximately %.2f.\n\n", "pi", Math.PI);

StdOut.printf("The %dth decimal digit of %.10f is %d.\n\n", 5, Math.PI, 9);

StdOut.printf("The speed of light is %.5e m/s.\n", 299792458.0);
```

Standard Output Revisted · Formatted Printing

Example

```
StdOut.printf("The value of %s is approximately %.2f.\n\n", "pi", Math.PI);

StdOut.printf("The %dth decimal digit of %.10f is %d.\n\n", 5, Math.PI, 9);

StdOut.printf("The speed of light is %.5e m/s.\n", 299792458.0);
```

writes

```
The value of pi is approximately 3.14.

The 5th decimal digit of 3.1415926536 is 9.

The speed of light is 2.99792e+08 m/s.
```

Standard Output Revisted · Example (Random Sequence)

Standard Output Revisted · Example (Random Sequence)

`RandomSeq.java`

Command-line input	n (int), lo (double), and hi (double)
Standard output	n random doubles, each from the interval $[lo, hi)$ and up to 2 decimal places

Standard Output Revisted · Example (Random Sequence)

RandomSeq.java

Command-line input	*n* (int), *lo* (double), and *hi* (double)
Standard output	*n* random doubles, each from the interval [*lo*, *hi*) and up to 2 decimal places

~/workspace/dsaj/programs

```
$ _
```

Standard Output Revisted · Example (Random Sequence)

RandomSeq.java

Command-line input	*n* (int), *lo* (double), and *hi* (double)
Standard output	*n* random doubles, each from the interval [*lo*, *hi*) and up to 2 decimal places

~/workspace/dsaj/programs

```
$ java RandomSeq 10 100 200
```

Standard Output Revisted · Example (Random Sequence)

RandomSeq.java

Command-line input	*n* (int), *lo* (double), and *hi* (double)
Standard output	*n* random doubles, each from the interval [*lo*, *hi*) and up to 2 decimal places

>_ ~/workspace/dsaj/programs

```
$ java RandomSeq 10 100 200
193.08
141.15
147.70
173.97
178.19
135.71
170.06
192.63
117.12
133.72
$ _
```

Standard Output Revisted · Example (Random Sequence)

Standard Output Revisted · Example (Random Sequence)

RandomSeq.java

```java
import stdlib.StdOut;
import stdlib.StdRandom;

public class RandomSeq {
    public static void main(String[] args) {
        int n = Integer.parseInt(args[0]);
        double lo = Double.parseDouble(args[1]);
        double hi = Double.parseDouble(args[2]);
        for (int i = 0; i < n; i++) {
            double r = StdRandom.uniform(lo, hi);
            StdOut.printf("%.2f\n", r);
        }
    }
}
```

Standard Input

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Standard input is input entered interactively on the terminal

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The end of standard input is signalled by the end-of-file (EOF) character (`<ctrl-d>`)

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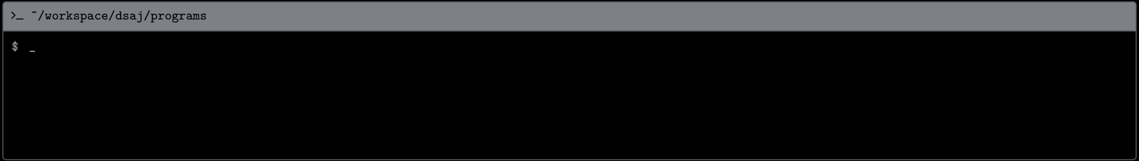

```
>_ ~/workspace/dsaj/programs

$ _
```

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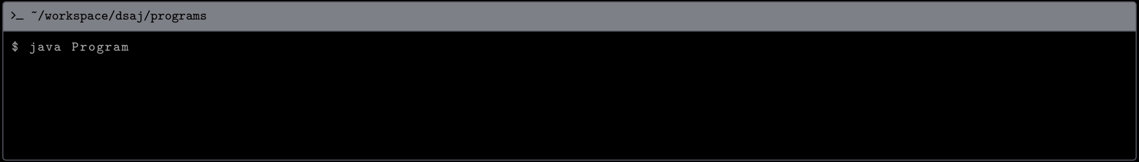

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
```

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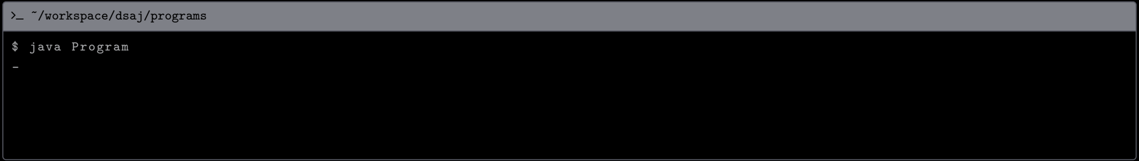

```
~/workspace/dsaj/programs
```

```
$ java Program
-
```

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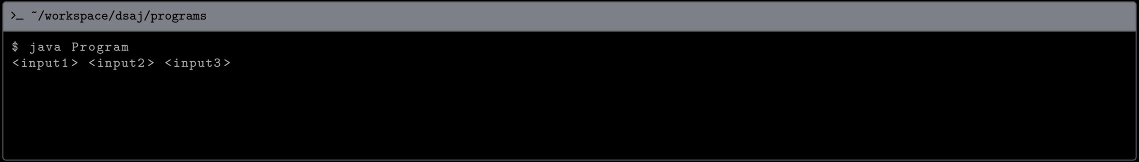

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
```

Standard Input

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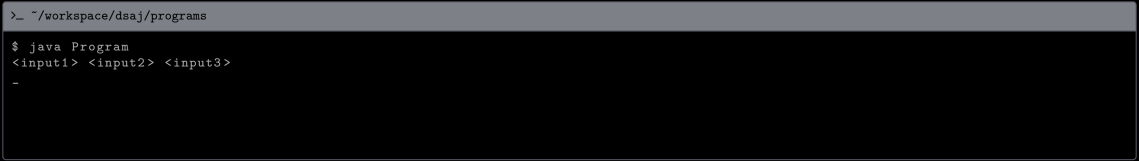

>_ ~/workspace/dsaj/programs

```
$ java Program
<input1> <input2> <input3>
_
```

Standard Input

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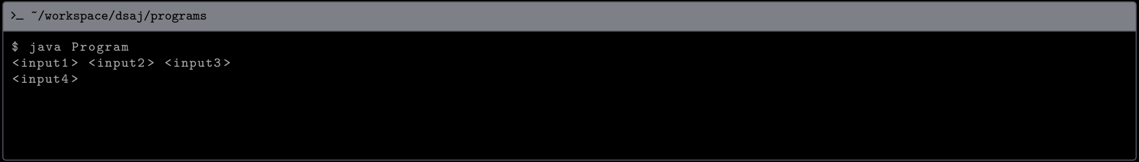

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
<input4>
```

Standard Input

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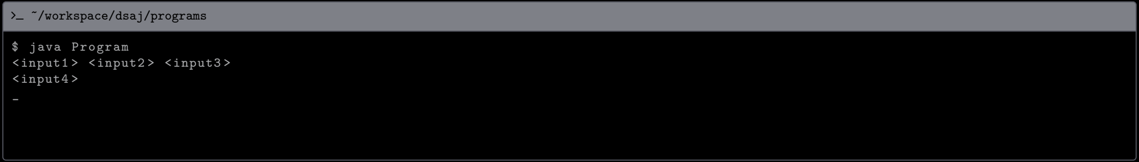

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
<input4>
_
```

Standard Input

Standard input is input entered interactively on the terminal

The end of standard input is signalled by the end-of-file (EOF) character (`<ctrl-d>`)

```
>_ ~/workspace/dsaj/programs

$ java Program
<input1> <input2> <input3>
<input4>
<input5> <input6>
```

Standard Input

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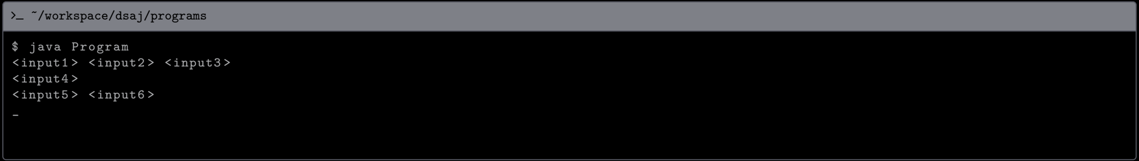

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
<input4>
<input5> <input6>
_
```

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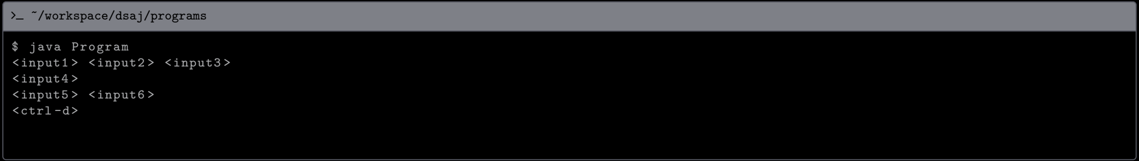

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
<input4>
<input5> <input6>
<ctrl-d>
```

Standard Input

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The end of standard input is signalled by the end-of-file (EOF) character (`<ctrl-d>`)

```
>_ ~/workspace/dsaj/programs
```

```
$ java Program
<input1> <input2> <input3>
<input4>
<input5> <input6>
<ctrl-d>
<program output>
$ _
```

Standard Input

Standard Input

☰ `stdlib.StdIn`

`static boolean isEmpty()`	returns `true` if standard input is empty, and `false` otherwise
`static int readInt()`	reads and returns the next int from standard input
`static double readDouble()`	reads and returns the next double from standard input

Standard Input · Example (Twenty Questions)

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TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

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~/workspace/dsaj/programs

```
$ _
```

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~/workspace/dsaj/programs

```
$ java TwentyQuestions
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? _
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

>_ ~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? _
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

>_ ~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? _
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
Too high
...
What is your guess? _
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	"Too low", "Too high", or "You win!"

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
Too high
...
What is your guess? 501694
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
Too high
...
What is your guess? 501694
Too high
What is your guess? _
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	"Too low", "Too high", or "You win!"

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
Too high
...
What is your guess? 501694
Too high
What is your guess? 501686
```

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

Standard input	user guesses
Standard output	“Too low”, “Too high”, or “You win!”

~/workspace/dsaj/programs

```
$ java TwentyQuestions
I am thinking of a secret number between 1 and 1000000
What is your guess? 500000
Too low
What is your guess? 750000
Too high
What is your guess? 625000
Too high
...
What is your guess? 501694
Too high
What is your guess? 501686
You win!
$ _
```

Standard Input · Example (Twenty Questions)

Standard Input · Example (Twenty Questions)

TwentyQuestions.java

```java
import stdlib.StdIn;
import stdlib.StdOut;
import stdlib.StdRandom;

public class TwentyQuestions {
    public static void main(String[] args) {
        int RANGE = 1000000;
        int secret = StdRandom.uniform(1, RANGE + 1);
        StdOut.printf("I am thinking of a secret number between 1 and %d\n", RANGE);
        int guess = 0;
        while (guess != secret) {
            StdOut.print("What is your guess? ");
            guess = StdIn.readInt();
            if (guess < secret) {
                StdOut.println("Too low");
            } else if (guess > secret) {
                StdOut.println("Too high");
            } else {
                StdOut.println("You win!");
            }
        }
    }
}
```

Standard Input · Example (Average)

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`Average.java`

Standard input	a sequence of doubles
Standard output	their average value

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>_ ~/workspace/dsaj/programs

```
$ _
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

~/workspace/dsaj/programs

```
$ java Average
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

~/workspace/dsaj/programs

```
$ java Average
_
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

>_ ~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
_
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

>_ ~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
3.0 7.0 32.0
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

>_ ~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
3.0 7.0 32.0
_
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

>_ ~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
3.0 7.0 32.0
<ctrl-d>
```

Standard Input · Example (Average)

Average.java

Standard input	a sequence of doubles
Standard output	their average value

~/workspace/dsaj/programs

```
$ java Average
1.0 5.0 6.0
3.0 7.0 32.0
<ctrl-d>
Average is 10.5
$ _
```

Standard Input · Example (Average)

Standard Input · Example (Average)

</> Average.java

```java
import stdlib.StdIn;
import stdlib.StdOut;

public class Average {
    public static void main(String[] args) {
        double total = 0.0;
        int count = 0;
        while (!StdIn.isEmpty()) {
            double x = StdIn.readDouble();
            total += x;
            count++;
        }
        double average = total / count;
        StdOut.println("Average is " + average);
    }
}
```

Standard Input · Example (Range Filter)

Standard Input · Example (Range Filter)

`RangeFilter.java`

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

>_ ~/workspace/dsaj/programs

```
$ _
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
_
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

>_ ~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
358 1330 55 165 689 1014 3066 387 575 843 203 48 292 877 65 998
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

>_ ~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
358 1330 55 165 689 1014 3066 387 575 843 203 48 292 877 65 998
358 165 387 203 292 _
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
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>_ ~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
358 1330 55 165 689 1014 3066 387 575 843 203 48 292 877 65 998
358 165 387 203 292 <ctrl-d>
```

Standard Input · Example (Range Filter)

RangeFilter.java

Command-line input	*lo* (int) and *hi* (int)
Standard input	a sequence of integers
Standard output	those integers that are in the range [*lo*, *hi*]

~/workspace/dsaj/programs

```
$ java RangeFilter 100 400
358 1330 55 165 689 1014 3066 387 575 843 203 48 292 877 65 998
358 165 387 203 292 <ctrl-d>
$ _
```

Standard Input · Example (Range Filter)

Standard Input · Example (Range Filter)

</> RangeFilter.java

```java
import stdlib.StdIn;
import stdlib.StdOut;

public class RangeFilter {
    public static void main(String[] args) {
        int lo = Integer.parseInt(args[0]);
        int hi = Integer.parseInt(args[1]);
        while (!StdIn.isEmpty()) {
            int x = StdIn.readInt();
            if (x >= lo && x <= hi) {
                StdOut.print(x + " ");
            }
        }
        StdOut.println();
    }
}
```

Redirection Operators · Output Redirection

Redirection Operators · Output Redirection

Output redirection operator (>)

Redirection Operators · Output Redirection

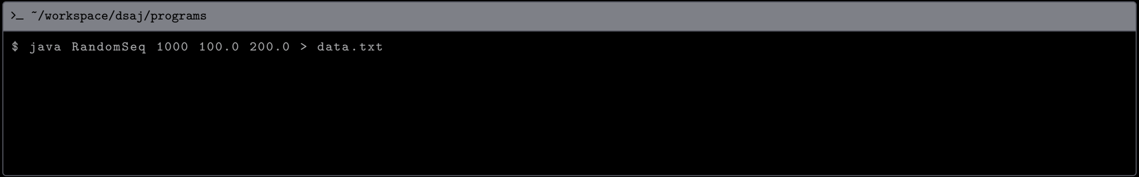
Output redirection operator (>)

```
>_ ~/workspace/dsaj/programs

$ _
```

Redirection Operators · Output Redirection

Output redirection operator (>)

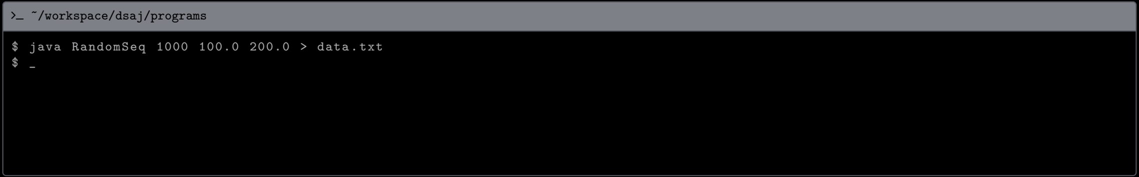


```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 > data.txt
```

Redirection Operators · Output Redirection

Output redirection operator (>)

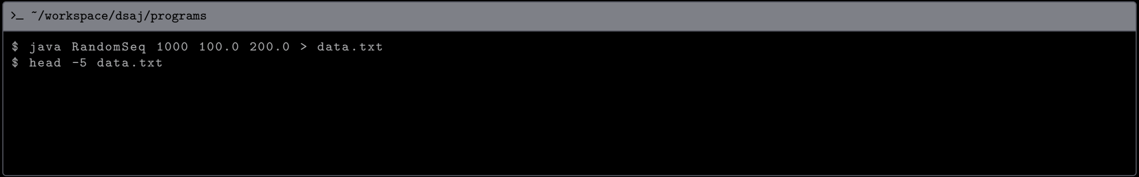


```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 > data.txt
$ _
```

Redirection Operators · Output Redirection

Output redirection operator (>)

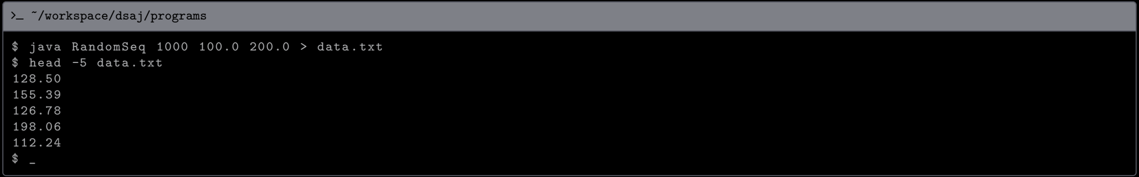


```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 > data.txt
$ head -5 data.txt
```

Redirection Operators · Output Redirection

Output redirection operator (>)



```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 > data.txt
$ head -5 data.txt
128.50
155.39
126.78
198.06
112.24
$ _
```

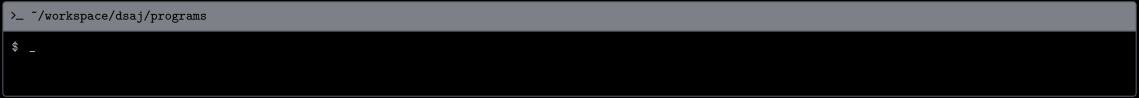
Redirection Operators · Input Redirection

Redirection Operators · Input Redirection

Input redirection operator (`<`)

Redirection Operators · Input Redirection

Input redirection operator (<)



```
>_ ~/workspace/dsaj/programs

$ _
```

Redirection Operators · Input Redirection

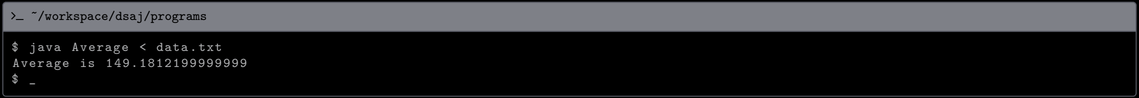
Input redirection operator (<)

```
>_ ~/workspace/dsaj/programs
```

```
$ java Average < data.txt
```

Redirection Operators · Input Redirection

Input redirection operator (<)



```
>_ ~/workspace/dsaj/programs
```

```
$ java Average < data.txt
Average is 149.1812199999999
$ _
```

Redirection Operators · Piping

Redirection Operators · Piping

Pipe operator (|)

Redirection Operators · Piping

Pipe operator (|)

```
>_ ~/workspace/dsaj/programs

$ _
```

Redirection Operators · Piping

Pipe operator (|)

```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 | java Average
```

Redirection Operators · Piping

Pipe operator (|)

```
>_ ~/workspace/dsaj/programs
```

```
$ java RandomSeq 1000 100.0 200.0 | java Average
Average is 150.0588699999999
$ _
```