“The Analytical Engine [computer] has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform.”

Ada Lovelace
Creator of first computer algorithm & programs
An Account of the Analytical Engine, 1842, reprinted in Faster than Thought, ed. B.V. Bowden (Pitman, 1953), cited in Andrew Hodges Alan Turing: The Enigma of Intelligence (Unwin 1985)
Binary

- Binary digit ("bit"): 0 or 1
- In binary arithmetic:
  - 0 means 0
  - 1 means 1
  - 10 means 2
  - 11 means 3
  - 100 means 4
  - 101 means 5
  - 110 means 6
  - 111 means 7
Structure of a Binary Number

\[
\begin{array}{cccccccccccc}
0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\
2^{11} & 2^{10} & 2^9 & 2^8 & 2^7 & 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \\
= 2^7 + 2^4 + 2^3 + 2^0 = 128 + 16 + 8 + 1 = 153
\end{array}
\]

So, the binary number \texttt{10011001} is the same as the decimal number \texttt{153}.

We write this as \texttt{10011001}_2 = \texttt{153}_10.

“\texttt{10011001} in base 2 equals 153 in base 10.” Base 2 is binary, base 10 is decimal.
Binary $\rightarrow$ Decimal

$1011_2 = 2^3 + 2^1 + 2^0$
$= 8 + 2 + 1$
$= 11_{10}$

$10010101001_2 = 2^{10} + 2^7 + 2^5 + 2^3 + 2^0$
$= 1024 + 128 + 32 + 8 + 1$
$= 1193_{10}$
Decimal $\rightarrow$ Binary

How do we go from decimal to binary?

For example: how do we write 19 in binary?

Strategy: start with largest power of two that is less than or equal to the number. Keep going down powers of two until you find which ones “fit into” the number.
Decimal → Binary

For example: how do we write 19 in binary?

Powers of 2 that “fit into” 19: 16, 8, 4, 2, 1

16 fits into 19
3 left: what is the largest power of two that fits into 3?
   2.
1 left, which fits into 1.
So, $16 + 2 + 1 = 19$, so:

$19_{10} = 10011_2$
Decimal $\rightarrow$ Binary

- What is the base 2 representation of $67_{10}$?
  
  A. 100011
  B. 111111
  C. 1000000
  D. 2111
  E. None of A-D are correct

- Write a method to convert a base 10 int to a base 2 String
The keyword list thus far:

- Complete list of Java keywords:

  abstract    default    if
  boolean    do         implements
  break       double     import
  byte        else       instanceof
  case        extends    int
  catch       finally    interface
  char        for        long
  class       float      native
  const       goto       new
  continue    enum       package
  assert
Methods that are tests

- Some methods return logical values (true or false).
  - A call to such a method is used as a `<test>` in a loop or if.

```java
Scanner console = new Scanner(System.in);
System.out.print("Type your first name: ");
String name = console.next();

if (name.startsWith("Dr.")) {
    System.out.println("Med school or PhD?");
} else if (name.endsWith("Esq.")) {
    System.out.println("And I am Ted 'Theodore' Logan!");
}
```
String test methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>equals(&lt;str&gt;)</td>
<td>whether two strings contain the same characters</td>
</tr>
<tr>
<td>equalsIgnoreCase(&lt;str&gt;)</td>
<td>whether two strings contain the same characters, ignoring upper vs. lower case</td>
</tr>
<tr>
<td>startsWith(&lt;str&gt;)</td>
<td>whether one contains other's characters at start</td>
</tr>
<tr>
<td>endsWith(&lt;str&gt;)</td>
<td>whether one contains other's characters at end</td>
</tr>
<tr>
<td>contains(&lt;str&gt;)</td>
<td>whether the given string is found within this one</td>
</tr>
</tbody>
</table>

```java
String name = console.next();
if (name.contains("Prof")) {
    System.out.println("When are your office hours?");
} else if (name.equalsIgnoreCase("mavEriCk")) {
    System.out.println("You're grounded, young man!");
}
```
Prompt the user for two words and report whether they:

- "rhyme" (end with the same last two letters)
- alliterate (begin with the same letter)

Example output: (run #1)
Type two words: car STAR
They rhyme!

(run #2)
Type two words: bare bear
They alliterate!

(run #3)
Type two words: sell shell
They alliterate!
They rhyme!

(run #4)
Type two words: extra strawberry
// Determines whether two words rhyme and/or alliterate.
import java.util.*;

public class Rhyme {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Type two words: ");
        String word1 = console.next().toLowerCase();
        String word2 = console.next().toLowerCase();

        // check whether they end with the same two letters
        if (word2.length() >= 2 &&
            word1.endsWith(word2.substring(word2.length() - 2))) {
            System.out.println("They rhyme!");
        }

        // check whether they alliterate
        if (word1.startsWith(word2.substring(0, 1))) {
            System.out.println("They alliterate!");
        }
    }
}
Random numbers

reading: 5.1
The Random class

- A Random object generates pseudo-random numbers.
  - Class Random is found in the java.util package.
    ```java
    import java.util.Random;
    ```

<table>
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<tr>
<th>Method name</th>
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<tbody>
<tr>
<td><code>nextInt()</code></td>
<td>returns a random integer</td>
</tr>
<tr>
<td><code>nextInt(&lt;max&gt;)</code></td>
<td>returns a random integer in the range [0, max) in other words, 0 to max-1 inclusive</td>
</tr>
<tr>
<td><code>nextDouble()</code></td>
<td>returns a random real number in the range [0.0, 1.0)</td>
</tr>
</tbody>
</table>

- Example:
  ```java
  Random rand = new Random();
  int randomNumber = rand.nextInt(10); // 0-9
  ```
Generating random numbers

- Common usage: to get a random number from 1 to \( N \)
  ```java
  int n = rand.nextInt(20) + 1;
  // 1-20 inclusive
  ```

- To get a number in arbitrary range \([min, max]\) inclusive:
  ```java
  <name>.nextInt(<size of range>) + <min>
  ```
  - Where \(<size of range>\) is \((<max> - <min> + 1)\)
  - Example: A random integer between 4 and 10 inclusive:
    ```java
    int n = rand.nextInt(7) + 4;
    ```
Random questions

Given the following declaration, how would you get:

Random rand = new Random();

- A random number between 1 and 47 inclusive?
  int random1 = rand.nextInt(47) + 1;

- A random number between 23 and 30 inclusive?
  int random2 = rand.nextInt(8) + 23;

- A random even number between 4 and 12 inclusive?
  int random3 = rand.nextInt(5) * 2 + 4;
What’s the pattern?

int n = <some integer>;
Random rand = new Random();
int randomNumber = a * rand.nextInt(n) + b;
Random and other types

- **nextDouble** method returns a double between [0.0 - 1.0)
  - Example: Get a random GPA value between 1.5 and 4.0:
    ```java
double randomGpa = rand.nextDouble() * 2.5 + 1.5;
```

- Any set of possible values can be mapped to integers
  - Code to randomly play Rock-Paper-Scissors:
    ```java
    int r = rand.nextInt(3);
    if (r == 0) {
        System.out.println("Rock");
    } else if (r == 1) {
        System.out.println("Paper");
    } else { // r == 2
        System.out.println("Scissors");
    }
    ```
Write a program that simulates rolling of two 6-sided dice until their combined result comes up as 7.

\[
\begin{align*}
2 + 4 &= 6 \\
3 + 5 &= 8 \\
5 + 6 &= 11 \\
1 + 1 &= 2 \\
4 + 3 &= 7 \\
\end{align*}
\]

You won after 5 tries!
// Rolls two dice until a sum of 7 is reached.
import java.util.*;

public class Dice {
    public static void main(String[] args) {
        Random rand = new Random();
        int tries = 0;

        int sum = 0;
        while (sum != 7) {
            // roll the dice once
            int roll1 = rand.nextInt(6) + 1;
            int roll2 = rand.nextInt(6) + 1;
            sum = roll1 + roll2;
            System.out.println(roll1 + " + " + roll2 + " = " + sum);
            tries++;
        }

        System.out.println("You won after " + tries + " tries!");
    }
}
Write a program that plays an adding game.

- Ask user to solve random adding problems with 2-5 numbers.
- The user gets 1 point for a correct answer, 0 for incorrect.
- The program stops after 3 incorrect answers.

4 + 10 + 3 + 10 = 27
9 + 2 = 11
8 + 6 + 7 + 9 = 25
Wrong! The answer was 30
5 + 9 = 13
Wrong! The answer was 14
4 + 9 + 9 = 22
3 + 1 + 7 + 2 = 13
4 + 2 + 10 + 9 + 7 = 42
Wrong! The answer was 32
You earned 4 total points.
// Asks the user to do adding problems and scores them.
import java.util.*;

public class AddingGame {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        Random rand = new Random();

        // play until user gets 3 wrong
        int points = 0;
        int wrong = 0;
        while (wrong < 3) {
            int result = play(console, rand);  // play one game
            if (result == 0) {
                wrong++;
            } else {
                points++;
            }
        }

        System.out.println("You earned " + points + " total points.");
    }
}
public static int play(Scanner console, Random rand) {
  // print the operands being added, and sum them
  int operands = rand.nextInt(4) + 2;
  int sum = rand.nextInt(10) + 1;
  System.out.print(sum);
  for (int i = 2; i <= operands; i++) {
    int n = rand.nextInt(10) + 1;
    sum += n;
    System.out.print(" + " + n);
  }
  System.out.print(" = ");

  // read user's guess and report whether it was correct
  int guess = console.nextInt();
  if (guess == sum) {
    return 1;
  } else {
    System.out.println("Wrong! The answer was " + total);
    return 0;
  }
}