CSE 121 Lesson 5:

Nested For Loops, Math, Random

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Spring 2024

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sli.do #cse121-5

Today's playlist:
CSE 121 lecture beats 24sp

Announcements, Reminders

- Creative Project 1 is out, due Tue April 16th
- Resubmission Cycle 0 released, due Thu Apr 18th
  - Eligible for submission: C0 & P0
  - Even if you're not resubmitting – read your feedback!!
- Revisiting the minimum grade guarantees

Last time: for loops!

For loops are our first *control structure*

- A syntactic structure that *controls* the execution of other statements.

```
for ( initialization ; test ; update ) {
    body (statements to be repeated)
}
```

Fencepost Pattern 1

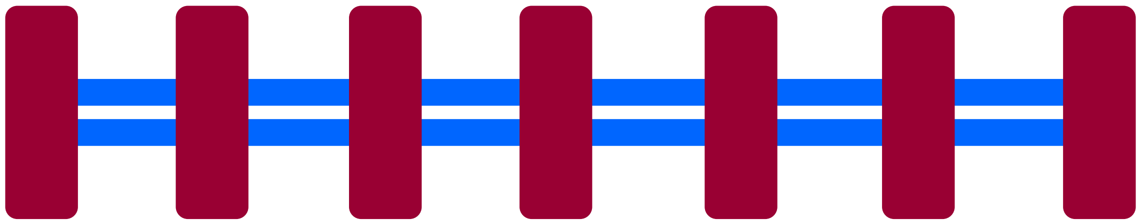
Some task where one piece is repeated *n* times, and another piece is repeated *n-1* times and they alternate

`h-u-s-k-i-e-s`

Fencepost Pattern 2

Some task where one piece is repeated *n* times, and another piece is repeated *n-1* times and they alternate

h-u-s-k-i-e-s



(PCM) Nested for loops

```
for (int outerLoop = 1; outerLoop <= 5; outerLoop++) {
    System.out.println("outer loop iteration #" + outerLoop);
    for (int innerLoop = 1; innerLoop <= 3; innerLoop++) {
        System.out.println("    inner loop iteration #" + innerLoop);
    }
    System.out.println(outerLoop);
}
```

Poll in with your answer!

sli.do #cse121-5

What output is produced by the following code?

```
for (int i = 1; i <= 5; i++) {
  for (int j = 1; j <= i; j++) {
    System.out.print(i);
  }
  System.out.println();
}
```

A.
```
1
12
123
1234
12345
```

B.
```
i
ii
iii
iiii
iiiii
```

C.
```
1
22
333
4444
55555
```

Poll in with your answer!

sli.do #cse121-5

What code produces the following output?

```
1
12
123
1234
12345
```

A.

```
for (int i = 1; i <= 5; i++) {
  for (int j = 1; j <= i; j++) {
    System.out.print(i);
  }
  System.out.println();
}
```

B.

```
for (int i = 1; i <= 5; i++) {
  for (int j = 1; j <= i; j++) {
    System.out.print(j);
  }
  System.out.println();
}
```

C.

```
for (int i = 1; i <= 5; i++) {
  for (int j = 1; i <= j; j++) {
    System.out.print(j);
  }
  System.out.println();
}
```

D.

```
for (int i = 1; i <= 5; i++) {
  for (int j = 1; j <= i; i++) {
    System.out.print(j);
  }
  System.out.println();
}
```

Pseudo-Randomness

Computers generate numbers in a predictable way using mathematical formulas.

Input may include current time, mouse position, etc.

True randomness is hard to achieve – we rely on natural processes

- e.g., atmospheric noise, lava lamps

Why randomness?

Randomness is a core part of computer science! It powers:

- cryptography
- security
- machine learning!

But <u>true</u> randomness is really hard. If we just use math, someone could "reverse" the formula.

So … lava lamps.

LavaRand: CloudFlare's Wall of Lava Lamps

(PCM) Random

A Random object generates *pseudo*-random numbers.

- The Random class is found in the `java.util` package

  ```
  import java.util.*;
  ```

- We can "seed" the generator to make it behave deterministically (helpful for testing!)

Method	Description
`nextInt()`	Returns a random integer
`nextInt(`*max*`)`	Returns a random integer in the range [0, *max*), or in other words, 0 to *max*-1 inclusive
`nextDouble()`	Returns a random real number in the range [0.0, 1.0)

Poll in with your answer!

sli.do #cse121-5

Assuming you've declared: `Random randy = new Random();`

Which of these best models picking a random card? (1-13 inclusive)

A. `randy.nextInt()`

B. `randy.nextInt(13)`

C. `randy.nextInt(13) + 1`

D. `randy.nextInt(14)`

(PCM) Math

Calling:

`Math.<method>(…)`

Method	Description
`Math.abs(`*value*`)`	Returns the absolute value of *value*
`Math.ceil(`*value*`)`	Returns *value* rounded up
`Math.floor(`*value*`)`	Returns *value* rounded down
`Math.max(`*value1*`, `*value2*`)`	Returns the larger of the two values
`Math.min(`*value1*`, `*value2*`)`	Returns the smaller of the two values
`Math.round(`*value*`)`	Returns *value* rounded to the nearest whole number
`Math.sqrt(`*value*`)`	Returns the square root of *value*
`Math.pow(`*base*`, `*exp*`)`	Returns *base* raised to the *exp* power

🍓🌮☕ Food for Thought 🥑🍱🧋

This week's food for thought is:

- one of matt's favourite areas of computer science
- less related to tech & society than the others…
- also the most ambitious, so don't stress about it – sit back, enjoy the ride :)

Wouldn't it be nice…

We've seen that some for loops go on forever:

```
for (int i = 0; i < 10; i--) {
  System.out.println(i);
}
```

```
for (;true;) {

}
```

Wouldn't it be nice if Java (or "the compiler") could catch this for us? I mean, the loop "obviously" never ends…

The Halting Problem (1/2)

Benedict Cumberbatch showed that it’s impossible to generally solve this problem.

Regardless of:

- how good (big, fast) your computer is
- how good your algorithm is
- **what people come up with the future!**

Given a Java program, it is impossible to always know if it eventually stops (or loops infinitely).

The Halting Problem (2/2)

~~Benedict Cumberbatch~~ **Alan Turing** showed that it's impossible to generally solve this problem.

Regardless of:

- how good (big, fast) your computer is
- how good your algorithm is
- **what people come up with the future!**

Given a Java program, it is impossible to always know if it eventually stops (or loops infinitely).

Alan Turing at 24 (1936). He had a storied (if also very tragic and short) life.

Many, many problems are <u>unsolvable</u>.

I don't mean "we currently don't know how to solve them".

I mean, **"there is no algorithm that will <u>ever</u> solve them"**.

Here are some related "**undecidable**" problems:

- given a Java program, are all the types correct?
- given a polynomial equation, does it have integer solution(s)?
- given any Magic: The Gathering board,
  does either player have a guaranteed winning strategy?

“This statement is false”

In fact, there’s an even more concerning result: there is at least one math statement that we can’t prove true or false.

What is that statement? It looks something like…

“This statement is false”.

In search of perfection

Even though we know it's "impossible", we still:

- try avoiding infinite loops
- type-check our Java programs
- play Magic: The Gathering (?)
- try to prove things in (and do) math!

Dessert for Thought!

I argue there are two takeaways:

1. Don’t let perfection be the enemy of the good!
   - applies to you in CSE 121 and as a programmer :)
   - fundamental basis of much of computer science
2. Like thinking about these sorts of problems?

   <u>This is also computer science!</u>

   (not all CS is just coding…) See: CSE 311, CSE 417/431