CSE 121 Lesson 5:

Nested `for` loops, `Math`, `Random`

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sli.do #CSE121-5

TAs:						
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Today's playlist:
CSE 121 24wi lecture beats :D

Announcements, Reminders

- Creative Project 1 is out, due Tues Jan 23rd
- Resubmission Cycle 0 released yesterday, due Thurs Jan 25th
  - Eligible for submission: C0 & P0
  - Even if you're not resubmitting – read your feedback!!
- reminder: no code screenshots (accessibility!)

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

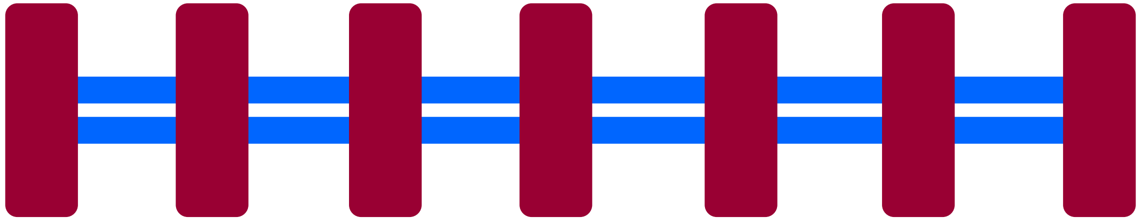
Some task where one piece is repeated *n* times, and another piece is repeated *n-1* times and they alternate

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

Fencepost Pattern

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!

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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!

What code produces the following output?

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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();
}
```

```
1
12
123
1234
12345
```

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

(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!

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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 <u>the most ambitious</u>, 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:

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

```java
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?

In search of perfection (1/2)

In fact, there's an even more concerning result: math itself is inconsistent.

There is at least one math statement that we can't prove true or false.

In search of perfection (2/2)

In fact, there's an even more concerning result: <u>math itself is inconsistent.</u>

There is at least one math statement that we can't prove true or false.

Yet, 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?

   This is also computer science!

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