ITP2200
Introduction to Software Testing

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Høyskolen Kristiania

Lecture 3
Logic Coverage
Input Space Partitioning

So, more programming this week?

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What do we remember from last time?

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We mentioned “Coverage”

```java
public class TriangleClassifier {
    public static String classify(int a, int b, int c) {

        if (a <= 0 || b <= 0 || c <= 0) {
            return "NOT_A_TRIANGLE";
        }

        if (a == b && b == c) {
            return "EQUILATERAL";
        }

        int max = Math.max(a, Math.max(b, c));

        if ((max == a && max - b - c >= 0) ||
                (max == b && max - a - c >= 0) ||
                (max == c && max - a - b >= 0)) {
            return "NOT_A_TRIANGLE";
        }

        if (a == b || b == c || a == c) {
            return "ISOSCELES";
        } else {
            return "SCALENE";
        }
    }
}
```

```java
@Test
public void testScalene() throws Exception {
    int a = 5;
    int b = 7;
    int c = 9;

    String result = TriangleClassifier.classify(a, b, c);
    assertTrue(result.equalsIgnoreCase( anotherString: "SCALENE"));

}

@Test
public void testIsosceles() throws Exception{
    int a = 5;
    int b = 5;
    int c = 7;

    String result = TriangleClassifier.classify(a, b, c);
    assertTrue(result.equalsIgnoreCase( anotherString: "ISOSCELES"));
    assertFalse(result.equalsIgnoreCase( anotherString: "SCALENE"));
}
```

Code is at
https://github.com/bogdanmarculescu/itp2200

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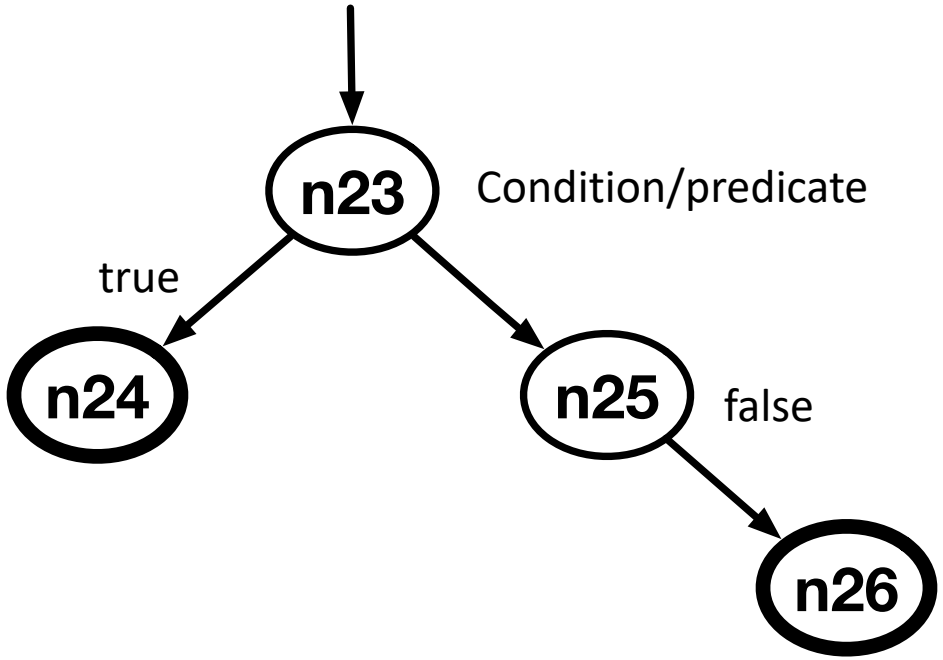
We mentioned “Coverage”

```
if (a == b || b == c || a == c) {
    return "ISOSCELES";
} else {
    return "SCALENE";
}
```



Code is at
https://github.com/bogdanmarculescu/itp2200

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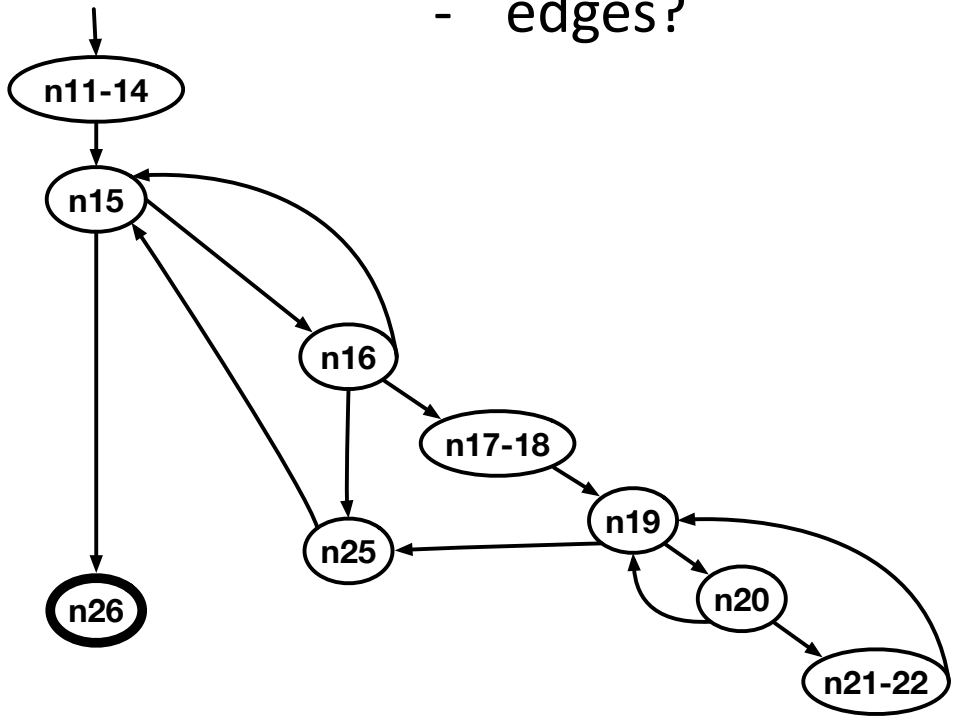
Code!!!

```java
public class PatternMatcher {
    public static int pat (char[] subject, char[] pattern)
    {
// Post: if pattern is not a substring of subject, return -1
// else return (zero-based) index where the pattern (first)
// starts in subject
        final int NOTFOUND = -1;
        int iSub = 0, rtnIndex = NOTFOUND; boolean isPat = false;
        int subjectLen = subject.length;
        int patternLen = pattern.length;
        while (isPat == false && iSub + patternLen - 1 < subjectLen) {
            if (subject [iSub] == pattern [0]) {
                rtnIndex = iSub; // Starting at zero
                isPat = true;
                for (int iPat = 1; iPat < patternLen; iPat ++) {
                    if (subject[iSub + iPat] != pattern[iPat]) {
                        rtnIndex = NOTFOUND; isPat = false;
                        break; // out of for loop
                    } }
            }
            iSub ++; }
        return (rtnIndex); }
}
```

How do we improve coverage?

- nodes?
- edges?



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Logical predicates and clauses

Predicates (and their expression in java)

- Negation: !variable
- And: var1 && var2
- Or: var1 || var2
- Xor: var1 ^ var2

- A condition evaluates to **true** or **false**

- **If, while, for –** all contain conditions

- E.g.:

isPat == false && iSub + patternLen -1 < subjectLen

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                for (int iPat = 1; iPat < patternLen; iPat ++) {
                    if (subject[iSub + iPat] != pattern[iPat]) {
                        rtnIndex = NOTFOUND; isPat = false;
                        break; // out of for loop
                    } }
            }
            iSub ++; }
        return (rtnIndex); }
}
```

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Logical predicates and clauses

Pred => isPat == false && x < y

Predicate coverage: pred is true, pred is false
(isPat == false and x<y , isPat == true)

Clause Coverage
isPat == true, x > y
isPat == false. x < y

Combinatorial coverage:
All possible combinations (8 in all)

BUT (it isn't x < y, is it?)
It's iSub + patternLen - 1 < subjectLen

```
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        int subjectLen = subject.length;
        int patternLen = pattern.length;
        while (isPat == false && iSub + patternLen - 1 < subjectLen) {
            if (subject [iSub] == pattern [0]) {
                rtnIndex = iSub; // Starting at zero
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                for (int iPat = 1; iPat < patternLen; iPat ++) {
                    if (subject[iSub + iPat] != pattern[iPat]) {
                        rtnIndex = NOTFOUND; isPat = false;
                        break; // out of for loop
                    } }
            }
            iSub ++; }
        return (rtnIndex); }
}
```

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Logical predicates and clauses

for (int iPat = 1; iPat < patternLen; iPat++)

Can be rewritten:

```
int iPat = 1;
while( iPat < patternLen){
   x = y/pattern[iPat];
   iPat++;
}
```

```
public class PatternMatcher {
    public static int pat (char[] subject, char[] pattern)
    {
// Post: if pattern is not a substring of subject, return -1
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                for (int iPat = 1; iPat < patternLen; iPat ++) {
                    if (subject[iSub + iPat] != pattern[iPat]) {
                        rtnIndex = NOTFOUND; isPat = false;
                        break; // out of for loop
                    } }
            }
            iSub ++; }
        return (rtnIndex); }
}
```

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Logical predicates and clauses

for (int iPat = 1; iPat < patternLen; iPat++)

Can be rewritten:

```
int iPat = 1;
while( iPat < patternLen && pattern[iPat]){
   x = y/pattern[iPat];
   iPat++;
}
```

-> Controllability comes in

```
public class PatternMatcher {
    public static int pat (char[] subject, char[] pattern)
    {
// Post: if pattern is not a substring of subject, return -1
// else return (zero-based) index where the pattern (first)
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        final int NOTFOUND = -1;
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        int subjectLen = subject.length;
        int patternLen = pattern.length;
        while (isPat == false && iSub + patternLen - 1 < subjectLen) {
            if (subject [iSub] == pattern [0]) {
                rtnIndex = iSub; // Starting at zero
                isPat = true;
                for (int iPat = 1; iPat < patternLen; iPat ++) {
                    if (subject[iSub + iPat] != pattern[iPat]) {
                        rtnIndex = NOTFOUND; isPat = false;
                        break; // out of for loop
                    } }
            }
            iSub ++; }
        return (rtnIndex); }
}
```

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Questions so far?

Back to triangles – value selection

```
5   public class TriangleClassifier {
6   @   public static String classify(int a, int b, int c) {
7
8           if (a <= 0 || b <= 0 || c <= 0) {
9               return "NOT_A_TRIANGLE";
10          }
11
12          if (a == b && b == c) {
13              return "EQUILATERAL";
14          }
15
16          int max = Math.max(a, Math.max(b, c));
17
18          if ((max == a && max - b - c >= 0) ||
19                  (max == b && max - a - c >= 0) ||
20                  (max == c && max - a - b >= 0)) {
21              return "NOT_A_TRIANGLE";
22          }
23
24          if (a == b || b == c || a == c) {
25              return "ISOSCELES";
26          } else {
27              return "SCALENE";
28          }
29      }
30  }
```

8: a <= 0 || b <= 0 || c <= 0
12: a == b && b == c
18: (max == a && max – b – c >= 0)
19: (max == b && max – a – c >= 0)
20: (max == c && max – a – b >= 0)

18a :18 || 19 || 20

24a: a == b
24b: b == c
24c: a == c

24: 24a || 24b || 24c

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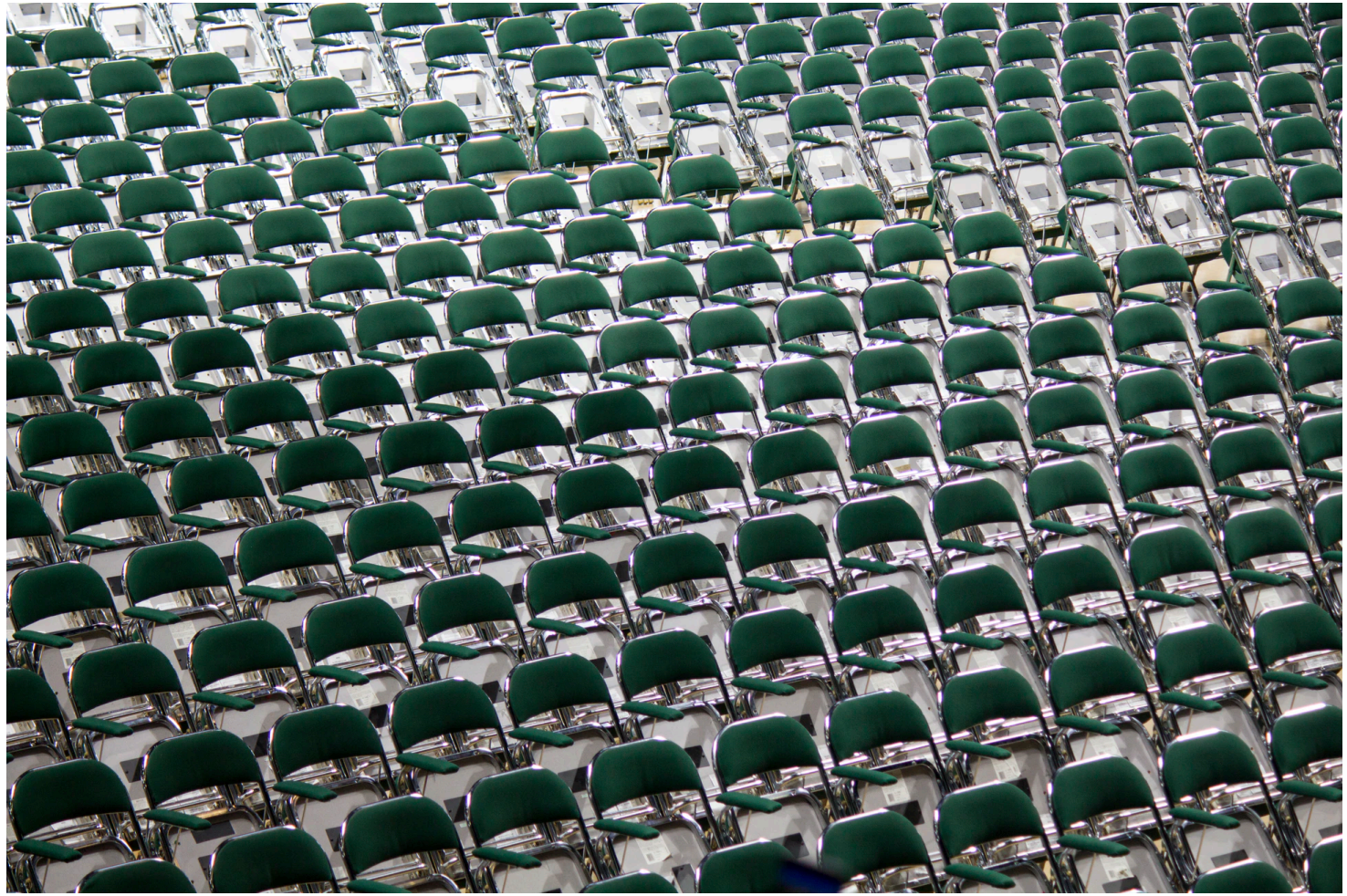
Input Space Partitioning



Domain: the space of all possible input values

Blocks: disjoint (i.e. non-overlapping) areas of the domain that are "equivalent" in some way

Partitioning: the process of splitting the domain into blocks

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Input Space Partitioning

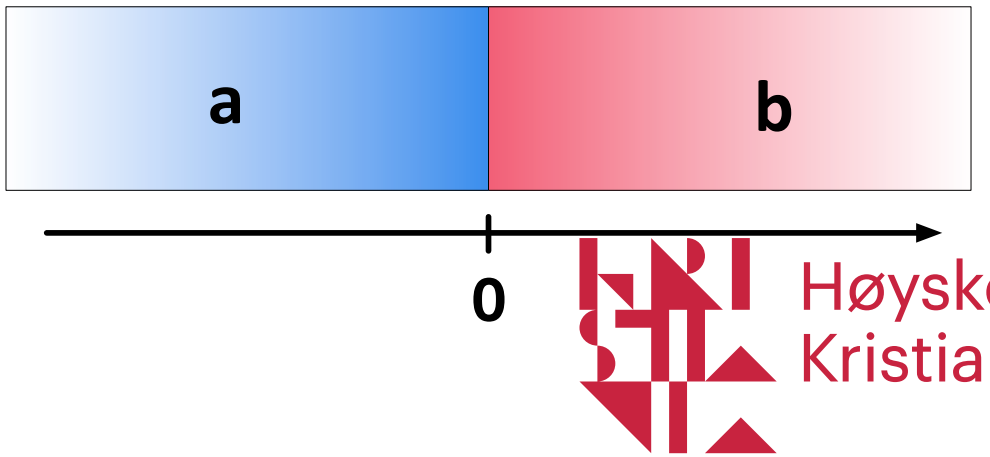
Equivalent
- similar **behaviour**, **output**,

- By some **criterion**

Equivalence classes:
Sections of the input space (i.e. collections of inputs) that result in equivalent behaviour from the system

```java
public static int categorize(int input){
    int result = 0;
    if (input > 0) {
        result = 1; //Return 1 if the number is positive
    }
    else {
        if (input < 0) result = -1; //Return -1 if the number is negative
    }
    return result;
}
```

```java
public static int absoluteValue(int input){
    if(input >= 0) return input;
    else return -input;
}
```



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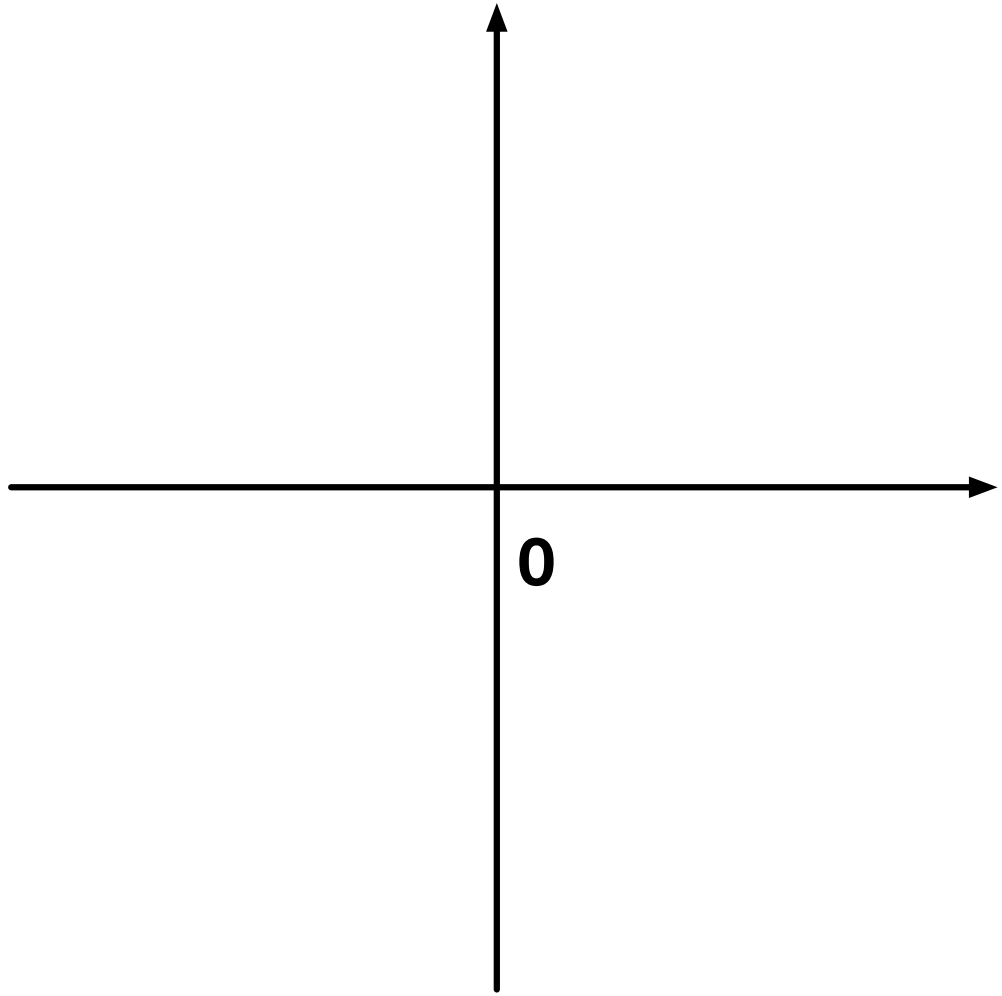
Input Space Partitioning




```
20  @   public static String quadrants(int x, int y){
21          if(x >= 0){
22              if(y>= 0){
23                  return "Upper-Right";
24              }
25              else{
26                  return "Lower-Right";
27              }
28          }
29          else {
30              if(y>=0){
31                  return "Upper-Left";
32              }
33              else{
34                  return "Lower-Left";
35              }
36          }
37      }
38
39  }
```

(3, 4)

(5, 4)

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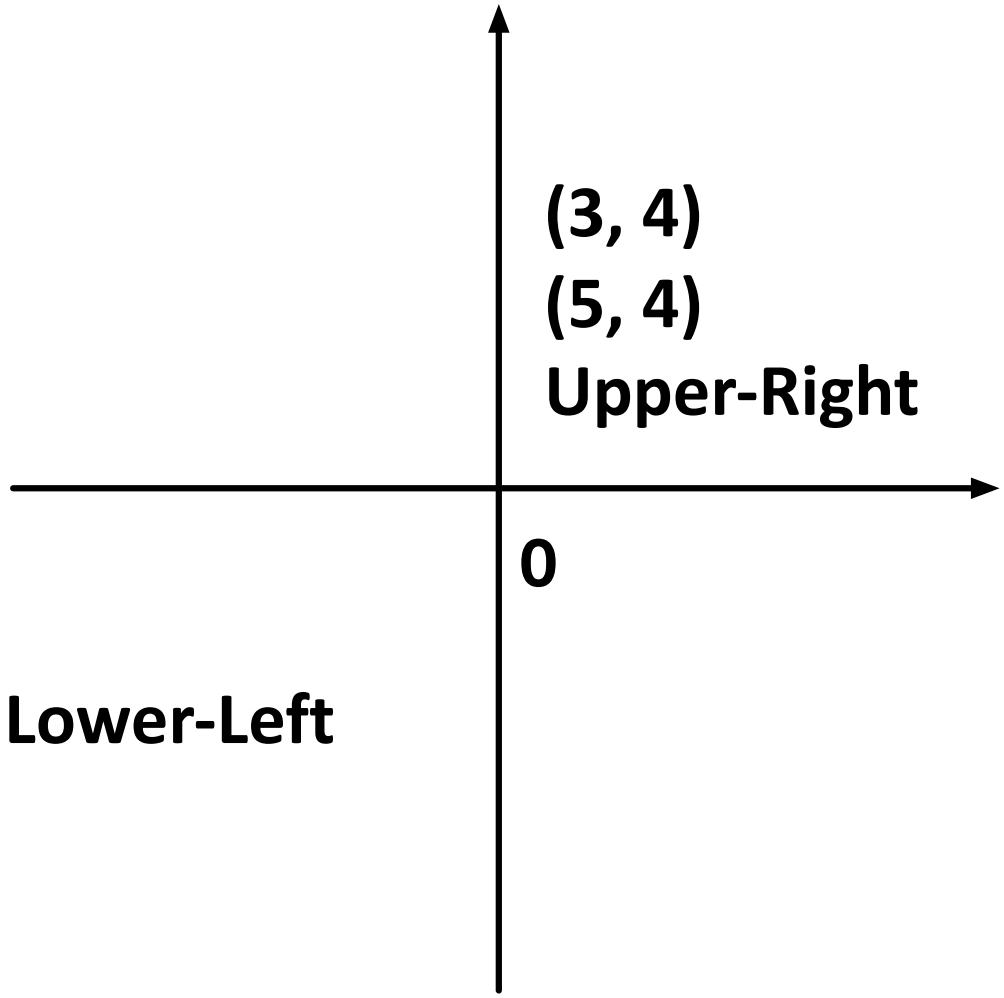
Input Space Partitioning

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27                  }
28              }
29              else {
30                  if(y>=0){
31                      return "Upper-Left";
32                  }
33                  else{
34                      return "Lower-Left";
35                  }
36              }
37          }
38
39      }
```

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Back to triangles – equivalence classes

```
5   public class TriangleClassifier {
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8           if (a <= 0 || b <= 0 || c <= 0) {
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```

What is the input domain?

How can we partition it?

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Back to triangles – equivalence classes

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        int max = Math.max(a, Math.max(b, c));

        if ((max == a && max - b - c >= 0) ||
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            return "NOT_A_TRIANGLE";
        }

        if (a == b || b == c || a == c) {
            return "ISOSCELES";
        } else {
            return "SCALENE";
        }
    }
}
```

What is the input domain?

How can we partition it?

Given an example of test values per partition:

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Equivalence Classes

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Equivalence Classes in Testing

Valid values:

Sub-partition:

Boundaries:

Normal use:

Invalid values:

Balance:

Missing partitions:

Overlapping partitions:

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Questions so far?

Exercise for the Seminar

Rooms:

A3-01

A4-03

A5-18

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Exercise for the Seminar

Note: you can save your existing work in a separate branch
git branch –b mywork

Self-organized.
In repo:
Ex04
For the methods in classes
TriangleClassifier
MathsAndStats

- Discuss the logical **predicates** (and what values would make them true and false)
- Define **input domain** and **partition** it (describe what blocks you find)
- Write at least one test case for each **equivalence class**

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Exercise for the Seminar

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Self-organized.
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Ex04
For the methods in classes

- Discuss the logical **predicates** (and what values would make them true and false)
- Define **input domain** and **partition** it (describe what blocks you find)
- Write at least one test case for each **equivalence class**

Advanced: PatternMatcher

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Exercise for the Seminar

When you're done,

Reflect on how this differs from the paths discussed last time.

Did the examples you tested last time cover all the equivalence classes?

Note: you can save your existing work in a separate branch
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