Principles of Software Construction

’tis a Gift to be Simple *or* Cleanliness is Next to Godliness

Midterm 1 and Homework 3 Post-Mortem

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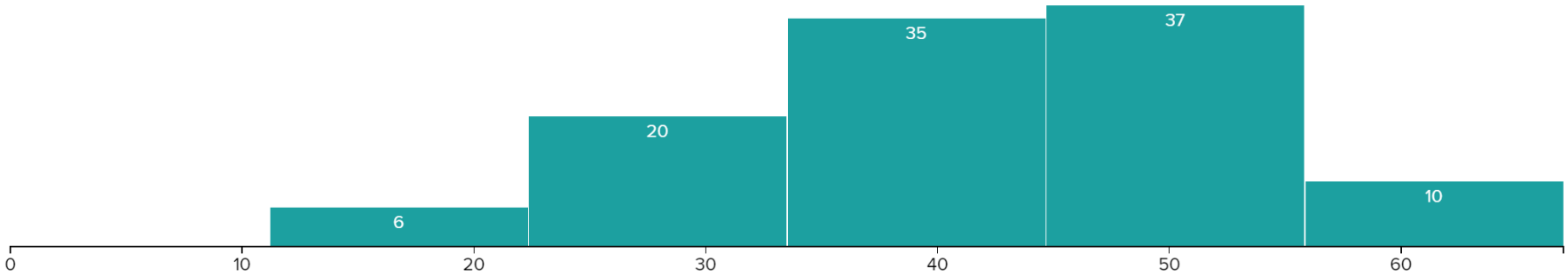
Administrivia

- Homework 4a due Thursday, 11:59 p.m.
  - Design review meeting is mandatory

Outline

- Midterm exam post-mortem
- Permutation generator post-mortem
- Cryptarithm post-mortem

Midterm exam results



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
16.0	42.5	63.0	41.24	10.9

Anyone know a simpler expression for this?

```
if (myDog.hasFleas()) {
    return true;
} else {
    return false;
}
```

Hint: it’s not this

```
return myDog.hasFleas() ? true : false;
```

Please do it this way from now on

We reserve the right to deduct points if you don't

```
return myDog.hasFleas();
```

Also, we saw some hash functions like these

```
return 31 * x + 31 * y;   // Multiplication doesn't help!

return 31 * x + 32 * y;   // Multiplication hurts!

return Objects.hash(map); // Objects.hash unnecessary!
```

Here's how these should look

```
return 31 * x + 31 * y;

return 31 * x + 32 * y;

return Objects.hash(map);
```

```
return 31 * x + y;

return 31 * x + y;

return map.hashCode();
```

What should a hash code look like, in general?

Standard Java hash functions - not great, but good enough

- Single-field object
  - `field.hashCode()`
- Two-field object
  - `31*field1.hashCode() + field0.hashCode()`
- 3-field object
  - `31*(31*field2.hashCode() + field1.hashCode) + field0.hashCode`
  - = 31^2 * field2.hashCode() + 31 * field1.hashCode() + field0.hashCode()
- N-field object
  - **Repeatedly multiply total by 31 and add in next field**
    - = $\Sigma\ 31^i \cdot \text{hashCode}(\text{field}_i)$
  - Alternatively: `Objects.hash(field`$_0$`, field`$_1$`, … field`$_{N-1}$`)`
- For much more information, see *Effective Java* Item 9

Some solutions were correct but repetitious

- **Repetition isn't just inelegant, it's toxic**
- Avoiding repetition is essential to good programming
- Provides not just elegance, but quality
- Ease of understanding aids in
  - Establishing correctness
  - Maintaining the code
- If code is repeated, each bug must be fixed repeatedly
  - If you forget to fix one occurrence, program is subtly broken
- Train yourself to feel a twinge of pain each time you copy-paste

A good, basic solution – fields and constructor (1/3)

What's the best internal representation if you want to support more base units?

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Design comparison for permutation generator

- Command pattern
  - Easy to code
  - Reasonably pretty to use
- Iterator pattern
  - Tricky to code because algorithm is recursive and Java lacks *generators*
  - Really pretty to use
- Performance is similar

A complete (!), general-purpose permutation generator

using the command pattern

How do you test a permutation generator?

Make a list of items to permute (integers should do nicely)

For each permutation of the list {
    Check that it's actually a permutation of the list
    Check that we haven't seen it yet
    Put it in the set of permutations that we have seen
}

Check that the set of permutations we've seen has right size (n!)

Do this for all reasonable values of n, and you're done!

And now, in code – this is the whole thing!

```
static void exhaustiveTest(int size) {
    List<Integer> list = new ArrayList<>(size);
    for (int i = 0; i < size; i++)
        list.add(i);
    Set<Integer> elements = new HashSet<>(list);

    Set<List<Integer>> alreadySeen = new HashSet<>();
    doForAllPermutations(list, (perm) -> {
        Assert.assertEquals(perm.size(), size);
        Assert.assertEquals(new HashSet(perm), elements);
        Assert.assertFalse("Duplicate", alreadySeen.contains(perm));
        alreadySeen.add(new ArrayList<>(perm));
    });
    Assert.assertEquals(alreadySeen.size(), factorial(size));
}

@Test public void test() {
    for (int size = 0; size <= 10; size++)
        exhaustiveTest(size);
}
```

Pros and cons of exhaustive testing

- Pros and cons of exhaustive testing
  + Gives you absolute assurance that the unit works
  + Exhaustive tests can be short and elegant
  + You don't have to worry about what to test
  − Rarely feasible; Infeasible for:
    - Nondeterministic code, including most concurrent code
    - Large state spaces
- **If you can test exhaustively, do!**
- If not, you can often approximate it with random testing

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A fast, fully functional cryptarithm solver in 6 slides

To refresh your memory, here's the grammar

```
cryptarithm ::= <expr> "=" <expr>
expr ::= <word> [<operator> <word>]*
word ::= <alphabetic-character>+
operator ::= "+" | "-" | "*"
```

Cryptarithm class (1) – fields

Conclusion

- Good habits really matter
  - "The way to write a perfect program is to make yourself a perfect programmer and then just program naturally." – Watts S. Humphrey, 1994
- Don't just hack it up and say you'll fix it later
  - You probably won't
  - but you will get into the habit of just hacking it up
- Representations matter! Choose carefully.
  - If your code is getting ugly, think again
  - "A week of coding can often save a whole hour of thought."
- Not enough to be merely correct; code must be clearly correct
  - Nearly correct is right out.