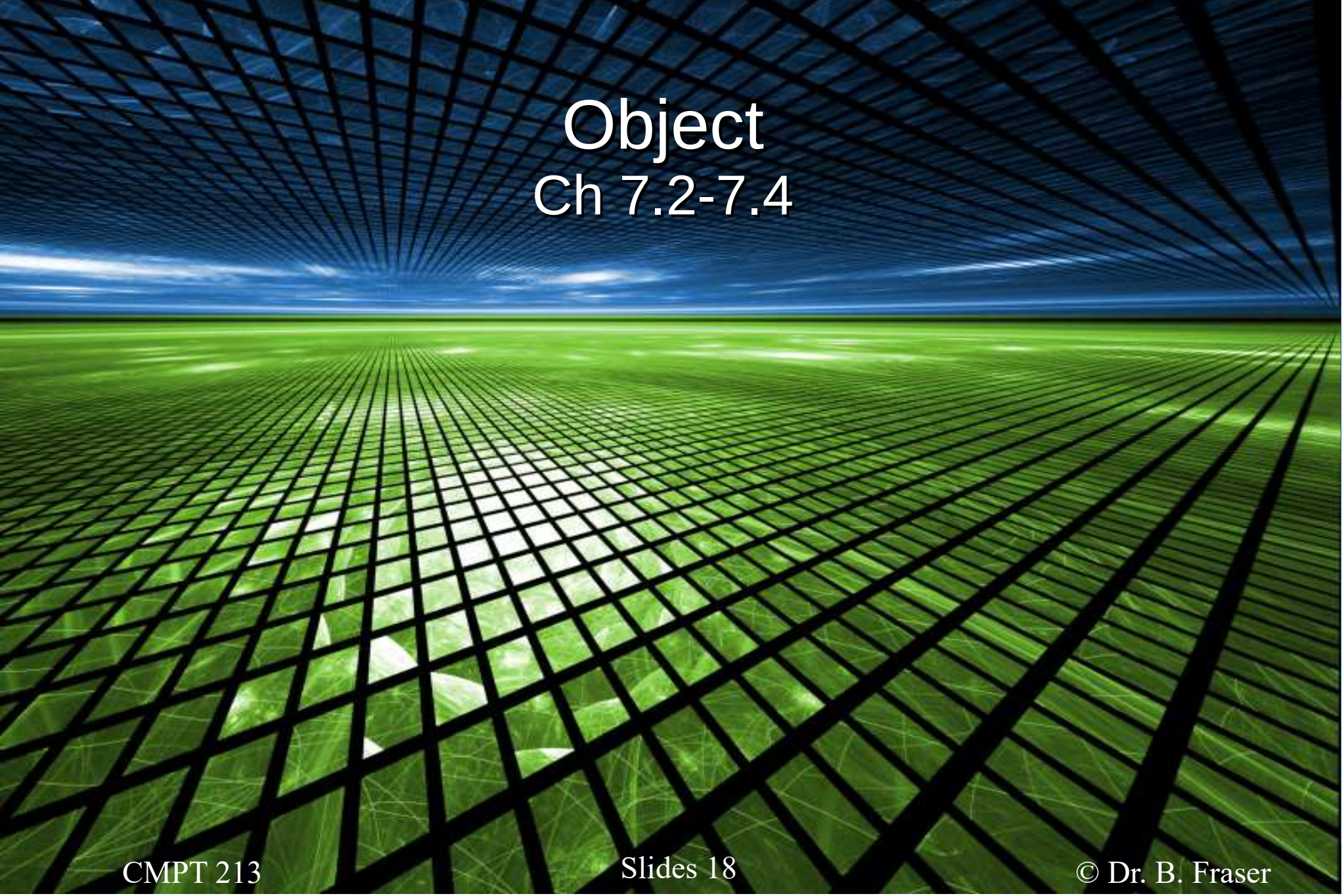


Topics

1) What does Object do for us?
   a) toString()
   b) equals()
   c) hashCode()
   d) clone()

   Gee, that's it? That should be simple, eh?!

toString()

toString()

- Automatically called when:
  - you concatenate an object with a string.
  - you print an object with print() or println().
- Default implementation
  - Object.toString() prints class name and hash code.
    ToStringExample@6876fb1b
- Reasonable toString() Structure

```
@Override
public String toString() {
   return getClass().getName()
      + "["
      + ... fields=values....
      + "]";
}
```

getClass() gets the..

..

..

getClass().getName()
returns the package name
and full class name.

toString() Guidelines

- toString() should:
  - return "a concise but informative representation that is easy for a person to read" [Javadocs for Object]
  - include all important fields in a human readable format
- Value Classes
  - For a "value" class (like PhoneNumber, Department) return..
    "(604) 123-4567", "CMPT"
  - Not for formatting complex objects for the UI:
    "Minion 'Horrible Harry' has 5 evil deeds"

    ..
- toString() not to replace getter functions;
  never get access to internals by parsing output of toString()

toString() w/ Inheritance

```
class Employee {
	private String name;
	private int salary;
	@Override
	public String toString() {
		return getClass().getName()
				+ "[name="+name
				+ ",salary="+salary
				+ "]";
	}
}

class Manager extends Employee {
	private int bonus;
	@Override
	public String toString() {
		return super.toString()
				+ "[bonus="+bonus
				+ "]";
	}
}
```

getClass().getName() gives the class of..

```
public static void main(String[] args) {
	Employee bob = new Employee(...);
	System.out.println(bob);

	Manager sarah = new Manager(...);
	System.out.println(sarah);
}
```

```
Employee[name=Bob,salary=50000]
Manager[name=Sarah,salary=100][bonus=200000]
```

equals()

equals()

- equals() checks if..

- Common error:

```
Car a, b;
if (a == b) {
    ...
}
```

Checks..

do a and b point to the same address?

- Should use:

```
if (a.equals(b)) {
    ...do something
}
```

But Object Provides:

```
public boolean equals(Object obj) {
..
}
```

Override equals() only when necessary

Equality

- Each class defines equals() as needed
  - Used by many classes to check equality.
    Ex: set checking for unique items.
  - Value classes (storing data) often need equals()
- Example: Strings
  - Two Strings equal if..
- Example: ICBC Database
  - Two Cars are equal if..
    even if different colours (likely one repainted)

Casting Safety

To use o, must cast to Car.
However, this can throw an exception.

```
class Car {
    @Override
    public boolean equals(Object o) {
```

Check o is..

(Must work for derived objects)

instanceof returns false
if o is null

```
        if (!(o instanceof Car)  return false;

        Car that = (Car) o;
    }
}
```

Complete equals()

```
class Car {
  private String make;
  private Date year;
  private int seating;
  private double weight;

  @Override
  public boolean equals(Object o) {
    if (o == this) return true;

    if (!(o instanceof Car)) return false;

    Car that = (Car) o;
    return Objects.equals(make, that.make)
        && Objects.equals(year, that.year)
        && seating == that.seating
        && Double.compare(weight, that.weight) == 0;
  }
}
```

- Check if same object (efficiency)
- Check other object is correct class.
- Cast and check fields

Checking fields for equal

- ..

  Objects.equals(field, that.field)
  - Correctly handles nulls and does not throw exception
  - Calls the field.equals() method.
- ..

  Double.compare(field, that.field) == 0
  - Correctly handles -0.0 vs +0.0, NaN, etc.
- int/short/long/bool/...

  field == that.field
- Skip fields which are not part of the object's logical state (cached values, etc).

```
class Car {
  private String make;
  private Date year;
  private int seating;
  private double wgt;

  @Override
  public boolean equals(Object o) {
     ...
    return Objects.equals(make, that.make)
      && Objects.equals(year, that.year)
      && seating == that.seating
      && Double.compare(wgt, that.wgt) == 0;
  }
}
```

equals() contract

- For non-null x and y, equals() must be:
  - ..
    x.equals(x) must be true
  - ..
    x.equals(y) iff y.equals(x)
    “x and y must agree if they are equal”
  - ..
    x.equals(y) && y.equals(z) means x.equals(z)
  - ..
    value of x.equals(y) unchanged for multiple invocations
  - ..
    x.equals(null) == false

Spot the Errors!

```
public class Truck {
    private String make;
    private Date year;
    private double weight;

    public boolean equals(Truck o) {
        if (this == null) return false;

        if (! (o instanceof Truck)) return false;



        return make.endswith(o.make)
                && weight == o.weight
                && year == o.year;

    }
}
```

instanceof aside

- Use instanceof instead of .getClass()
- Checking identical class violates LSP:
  getClass() == o.getClass()
  only true for identical class
  - Cannot have a derived class..
  - Used with proxy classes, etc.
- With inheritance, instanceof can hit symmetry issues
  car.equals(sportsCar)
  sportsCar.equals(car)
  - equals() is hard with inheritance!

Violates LSP

```
public boolean equals(Object o) {
  if (o == null) return false;
  if (o.getClass() != getClass())
     return false;

  Car that = (Car) o;
  return ...;
}
```

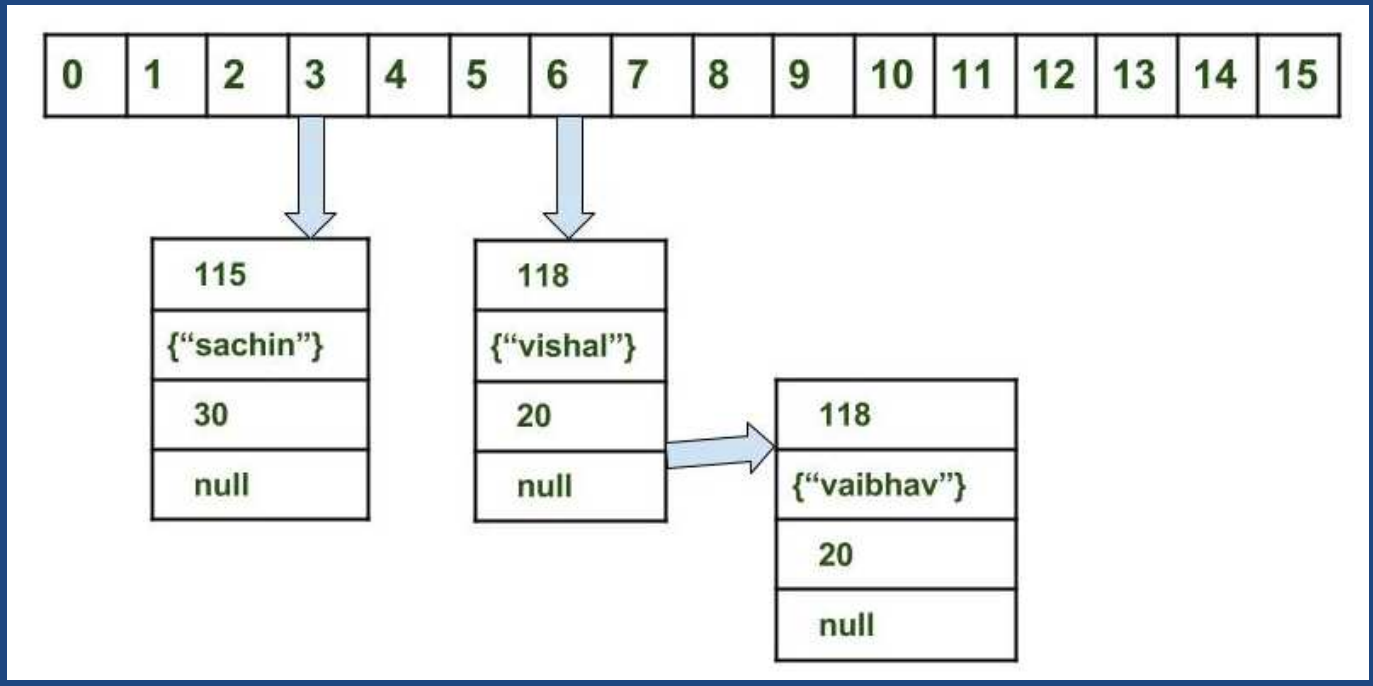
```
  if (!(o instanceof Car))
     return false;
vs
  if (!(o instanceof SportsCar))
     return false;
```

"There is no way to extend an instantiable class
and add a value component while preserving the equals contract."
- Joshua Bloch (Effective Java 3rd ed; p42)

hashCode()

hashCode()

- A hash code is..
  - Used in hash-maps/hash-sets.
  - Object's hashCode() hashes the memory address.



Full Example

```
class Car {
  private String make;
  private Date year;
  private int seating;
  private double weight;

  @Override
  public boolean equals(Object o) {
    if (o == this) return true;
    if (!(o instanceof Car)) return false;

    Car that = (Car) o;
    return Objects.equals(make, that.make)
       && Objects.equals(year, that.year)
       && seating == that.seating
       && Double.compare(weight, that.weight) == 0;
  }

  @Override
  public int hashCode() {
    return Objects.hash(make, year, seating, weight);
  }
}
```

- Use Objects.hash()
  - Pass all fields which store state.

hashCode() and equals()

- If overriding equals(),..
  - Hash tables use both methods to find elements:
    Use hashCode() to find the “bin”
    Use equals() to find the object inside the “bin”.
- ..
  - Otherwise collections may not work correctly with the class!
  - Use the same set of fields for computing equals() as for hashCode().

What is wrong with the following?

```
@Override
public int hashCode() {
    return 42;
}
```

Works!
But terrible efficiency!

```
public class Bucket {
    private String label;
    private double cost;

    public boolean equals(Object o) {
        // ... some code omitted...
        return label.equals(o.label);
    }

    public int hashCode() {
        return Objects.hash(cost, label);
    }
```

Missing @Override (optional)

Depending on field not used in equals!

x and y might show as equal(); however have different hashCode() values!

Inheritance with equals() & hashCode()

- Defer to base class the work on the base class's fields.

```
// Note: Poor use of inheritance to add a value to
//       an instantiable class... but anyway.
class SportsCar extends Car{
    private int topSpeed;

    @Override
    public boolean equals(Object o) {
        if (!super.equals(o)) return false;

        if (!(o instanceof SportsCar)) return false;
        SportsCar sportsCar = (SportsCar) o;

        return topSpeed == sportsCar.topSpeed;
    }

    @Override
    public int hashCode() {
        return Objects.hash(super.hashCode(), topSpeed);
    }
}
```

Breaks symmetry

clone()

DANGER!

- clone() is for duplicating objects.
- Want to know about clone?
  - Go read Effective Java 3rd ed by Joshua Bloch, Item 13

(Not covered here!)

- Use judiciously!

Summary

- Subtilties with Object:
  - toString():
    - For UI only if a simple data object
    - Call super.toString() when needed
  - equals():
    - Check type, cast, check equals
    - Watch for null fields
  - hashCode():
    - Override with equals()
    - Consistent with equals()