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M3 (a) – Object State

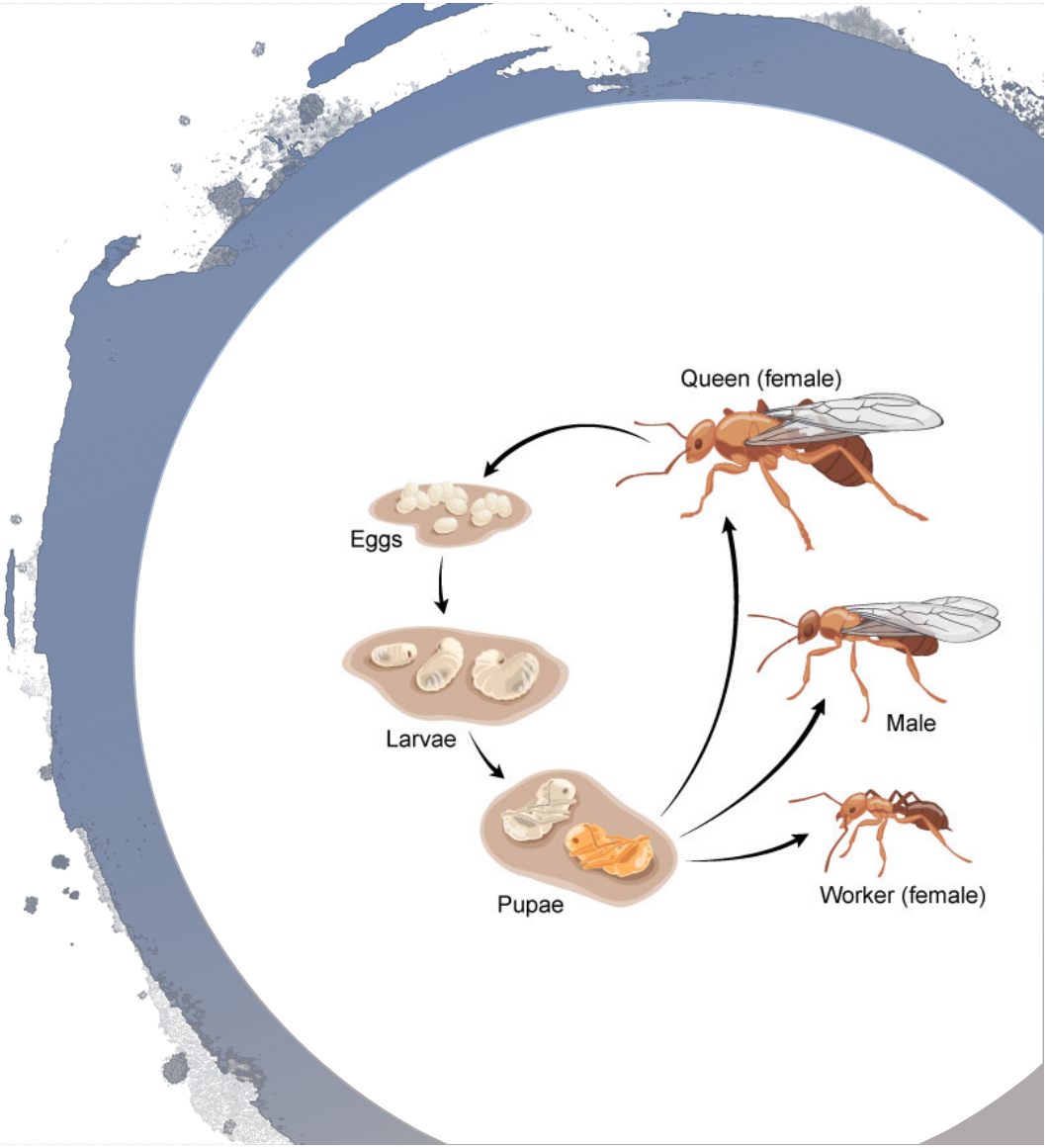
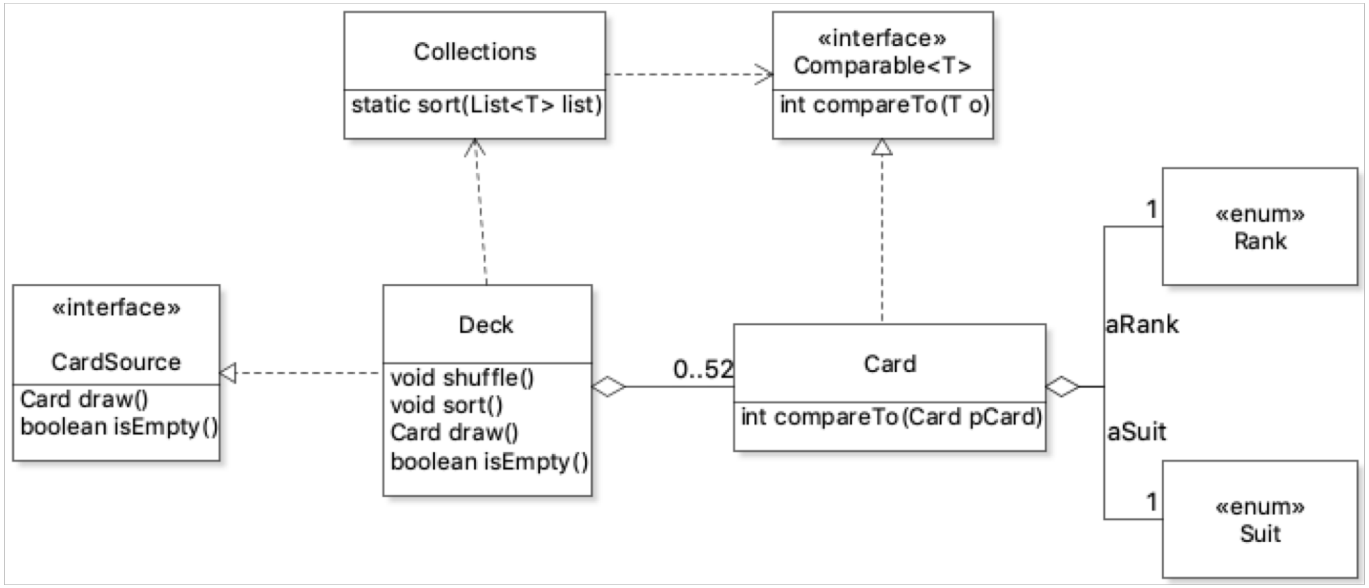


Image Source: https://askabiologist.asu.edu/individual-life-cycle

Objective

- Static vs. Dynamic Perspective on Software
- Concrete vs. Abstract Object State
- Object Life Cycle, State Diagram
- Nullability
- Object Identity
- Object Equality

Static View of the Software

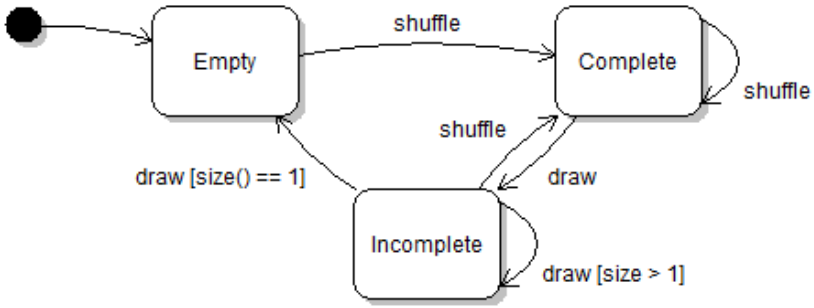


UML Class Diagram

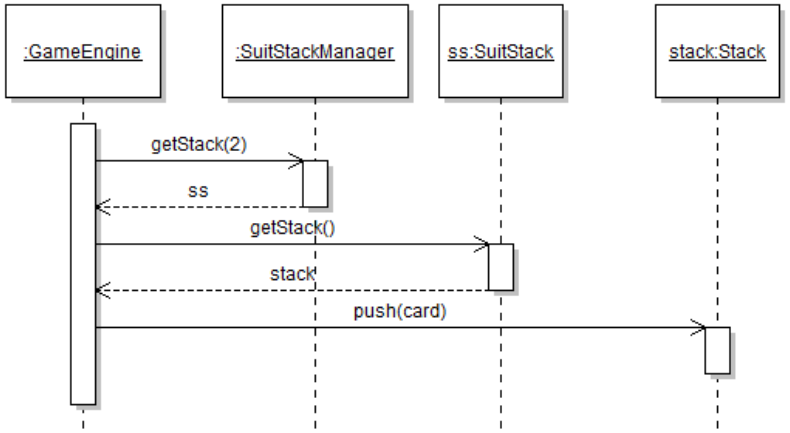
Illustrate how classes are defined

How about the software behaviors run-time?

Dynamic View of the Software



State Diagram



Sequence Diagram

How about the software behaviors run-time?

Object at Run-time

```
public final class Card
{
    private final Rank aRank;
    private final Suit aSuit;
}
```

{*ACE*, *TWO*, *THREE*, *FOUR*, *FIVE*, *SIX*, *SEVEN*, *EIGHT*, *NINE*, *TEN*, *JACK*, *QUEEN*, *KING*}

{*CLUBS*, *DIAMONDS*, *HEARTS*, *SPADES*}

13x4 possible state

Concrete state of the object

Object at Run-time

Abstract State is needed

```
public class Word {
    // Representation of a word in its original form
    // as in one sentence.
    final private String orignialForm;
}
```

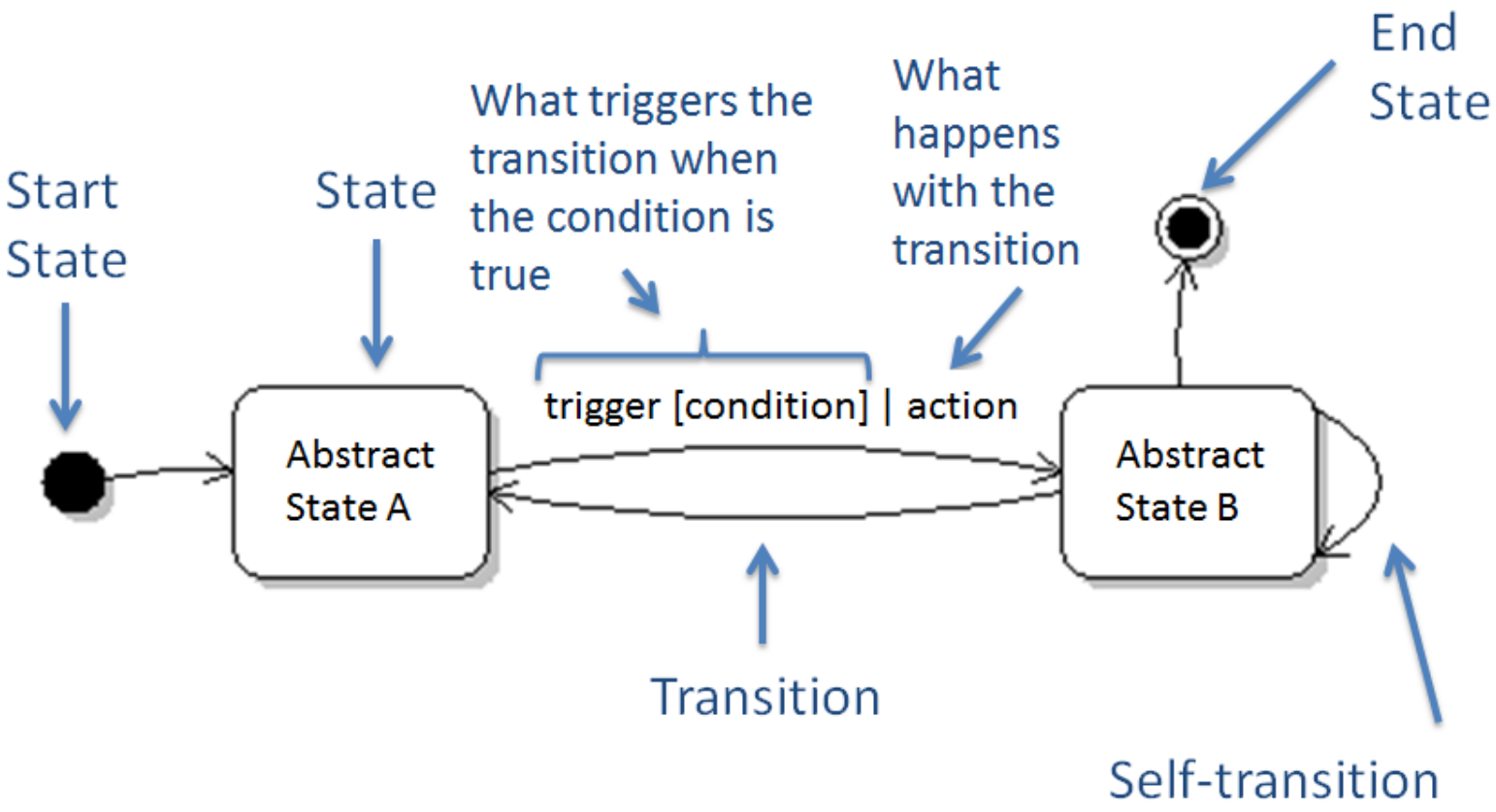
Concrete state of the object
(2^31 – 1) X 2^16 !

State Diagram

- Abstract States

- Transitions between states

State Diagram



State Diagram for Deck Object

- Demo of using JetUML for two Deck Designs

Design Constructor

- A constructor should fully initialize the object
  - The class invariant should hold
  - Shouldn't need to call other methods to “finish” initialization

Design Field

- Has a value that retains meaning throughout the object's life
- Its state must persist between public method invocations

General Principle

- Minimize the state space of object to what is absolutely necessary
  - It’s impossible to put the object in an invalid of useless state
  - There’s no unnecessary state information

Nullability (absence of value)

```
Card card = null;
```

A viable is temporarily un-initialized and will be initialized in a different state.

A viable is incorrectly initialized. The code of initiation is not executed properly.

As a flag that represents the absence of a useful value

Special use.

```
Card.Rank rank = card.getRank();
```

Avoid *null* values when designing classes!

How to avoid Null

- Through Contract

Make Null invalid for a variable

```
/**
* @param pRank The index of the rank in RANKS
* @param pSuit The index of the suit in SUITS
* @pre pRank != null && pSuit != null
*/
public Card(Rank pRank, Suit pSuit)
{
   if (pRank != null || pSuit == null)
   aRank = pRank;
   aSuit = pSuit;
}
```

How to avoid Null

- Sometimes it’s necessary to model absence of value

Activity

- Discuss your design of the extension of class Card where one instance can also represent a ”Joker”. (M1-Exercise, #2)

  Note: Joker is special card with no rank and no suit.

Image source: https://upload.wikimedia.org/wikipedia/commons/6/6f/Joker_Card_Image.jpg

```
public class Card
{
   private Rank aRank;
   private Suit aSuit;
   private boolean aIsJoker;
```

Arbitrary (valid) value for rank and suit?

Add special value for Rank and Suit enums?

java.util.Optional<T>

- A container object which may or may not contain a non-null value.
- If a value is present, isPresent() will return true and get() will return the value.

```
public class Card
{
   private Optional<Rank> aRank;
   private Optional<Suit> aSuit;
   private boolean aIsJoker;
```

```java
public Card(Rank pRank, Suit pSuit)
{
  assert pRank != null && pSuit != null;
  aRank =  Optional.of(pRank);
  aSuit = Optional.of(pSuit);
}

public Card()
{
  aIsJoker = true;
  aRank = Optional.empty();
  aSuit = Optional.empty();
}
```

What about getter methods?

- Return Optional<T> types

- Up-wrap Optional and return T

Object Identity

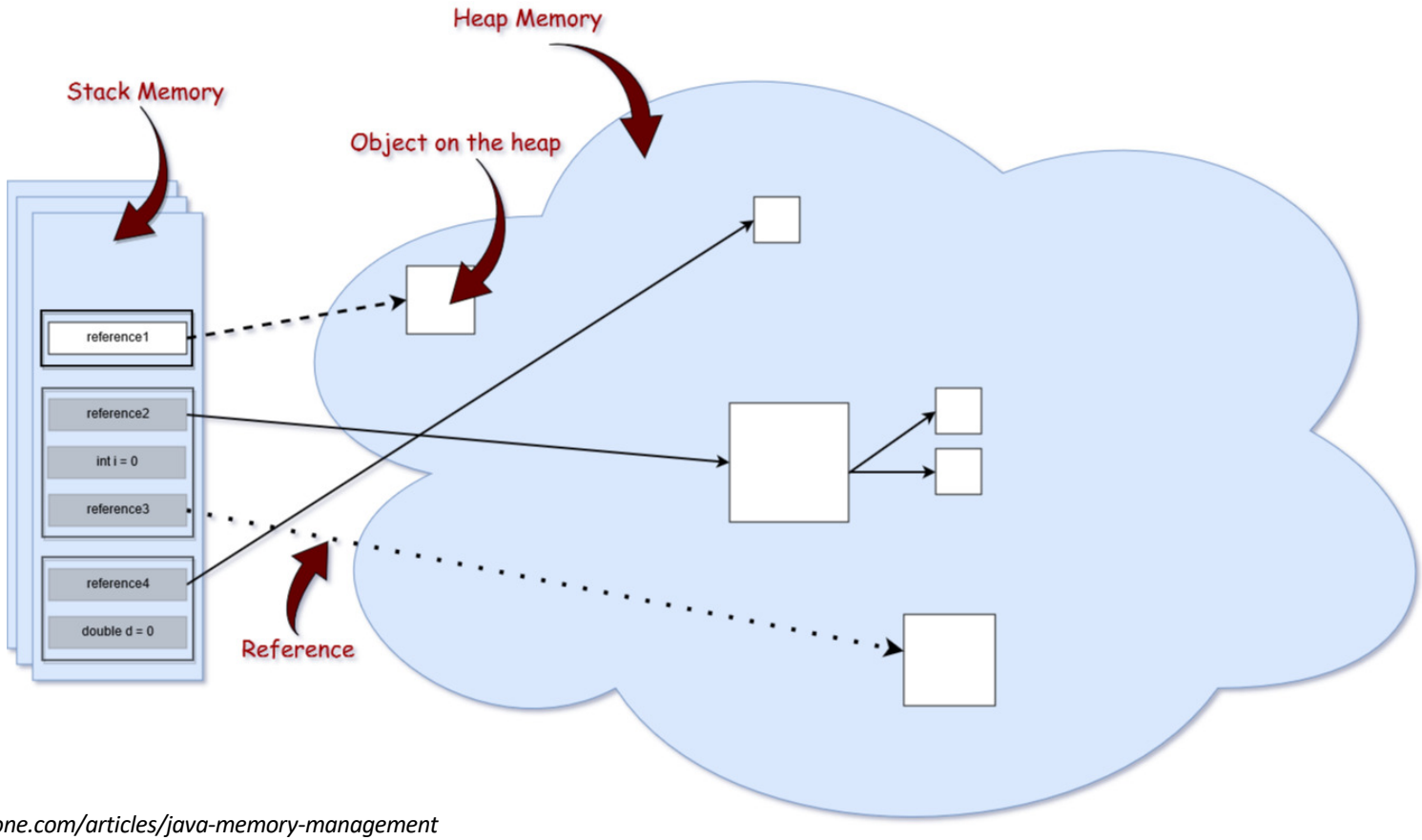
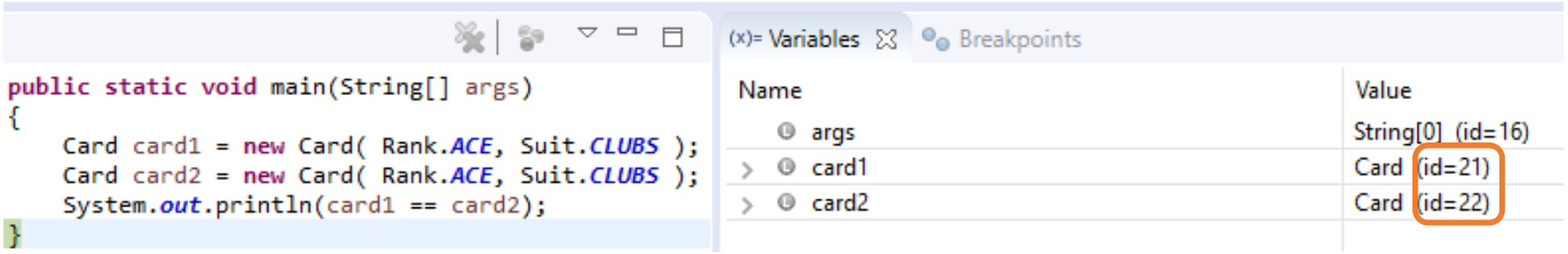


Image Source: https://dzone.com/articles/java-memory-management

Object Identity



True or False?

```
Card card1 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card2 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card3 = card1;

System.out.println(card1 == card2);
System.out.println(card1 == card3);
System.out.println(card1.equals(card2));
System.out.println(card1.equals(card3));
```

Object Equality

```
Card card1 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card2 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card3 = card1;

System.out.println(card1 == card2);
System.out.println(card1 == card3);
System.out.println(card1.equals(card2));
System.out.println(card1.equals(card3));
```

Reference equality

Variables refer to (point to) the same object in the memory

Object.equals method

```
public class Object {
   public boolean equals(Object o) {
      return this == o; // reference equality
   }
}
```

Implements an equivalence relation on non-null object references.

Reflexive: x.equals(x) == true

Symmetric: x.equals(y) ⇔ y.equals(x)

Transitive: x.equals(y) ∧ y.equals(z) ⇔ x.equals(z)

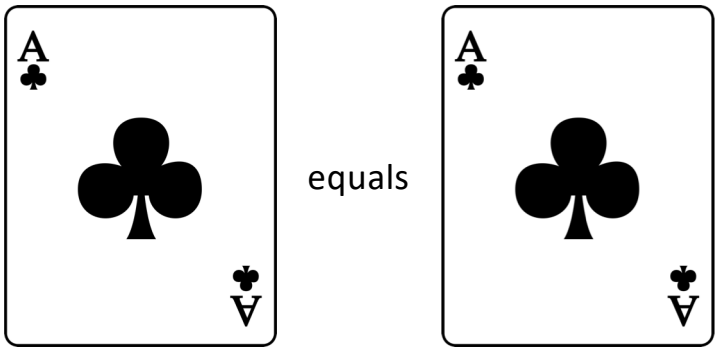
Consistent: x.equals(x) == x.equals(x)

For non-null reference value x x.equals(null) == false

Object.equals method

- The most discriminating possible equivalence relation on objects

What about when logical equality is needed?



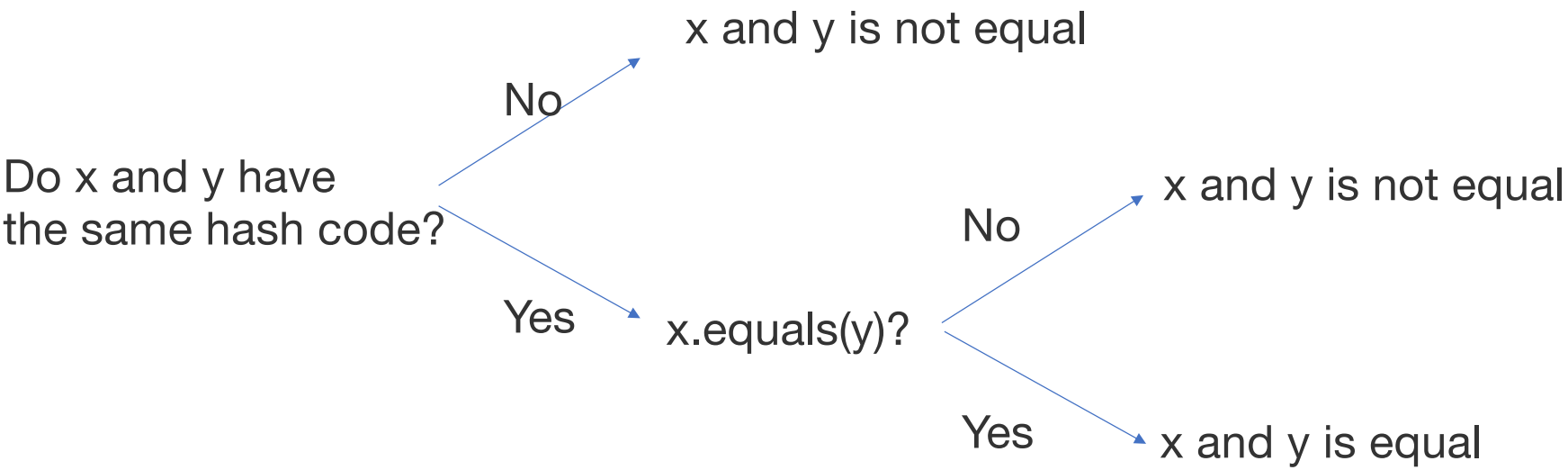
Override equals method

```
@Override
public boolean equals(Object obj) {
   if (this == obj) return true;
   if (obj == null) return false;

   if (getClass() != obj.getClass())
      return false;

   Card other = (Card) obj;

   return aIsJoker == other.aIsJoker
      && aRank.equals(other.aRank)
      && aSuit.equals(other.aSuit)
}
```

True or False (after overriding equals)?

```
Card card1 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card2 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
Card card3 = card1;

System.out.println(card1 == card2);
System.out.println(card1 == card3);
System.out.println(card1.equals(card2));
System.out.println(card1.equals(card3));
```

Prefiltering for equality



Object.hashCode method

```
public int hashCode()
```

Returns a hash code value for the object. This method is supported for the benefit of hash tables such as those provided by HashMap.

Self-Consistent: o.hashCode() == o.hashCode()

Consistent with Equals:

x.equals(y) => x.hashCode() == y.hashCode()

Override hashCode() method

```
@Override
public int hashCode() {
    return 1;
}

@Override
public int hashCode() {
       return Boolean.hashCode(aIsJoker)
              + aRank.hashCode()
              + aSuit.hashCode();
}
```

Equality during Inheritance

```
public class CardWithDesign extends Card {
    public enum Design{ CLASSIC, ARTISTIC, FUN}

    Design aStyle;

    public CardWithDesign(Rank pRank, Suit pSuit, Design aStyle) {
        super(pRank, pSuit);
        this.aStyle = aStyle;
    }
    public CardWithDesign(Design aStyle) {
        super();
        this.aStyle = aStyle;
    }
}
```

```
Card card1 = new CardWithDesign(Card.Rank.FOUR, Card.Suit.CLUBS,
       CardWithDesign.Design.ARTISTIC);
Card card2 = new CardWithDesign(Card.Rank.FOUR, Card.Suit.CLUBS,
       CardWithDesign.Design.CLASSIC);

System.out.println(card1.equals(card2));
```

```
Card card3 = new Card(Card.Rank.FOUR, Card.Suit.CLUBS);
System.out.println(card1.equals(card3));
System.out.println(card3.equals(card1));
```

Violate Symmetric property

```
System.out.println(card2.equals(card3));
```

Violate Transitive property

Solution?

Make the comparison between supertype and subtype return false

Favor composition over inheritance (More on Module 5)