- Previous lecture:
  - Why use OOP?
  - Attributes for properties and methods
- Today's lecture:
  - Inheritance: extending a superclass
  - Overriding methods in superclass
  - Next topic: Recursion
- Announcement:
  - Project 6 due on Dec 3rd (Thurs) at 11pm.
  - Remember academic integrity! We will check all submissions using MOSS.
  - Final exam on Wednesday, Dec 9th, at 7pm. Email Randy Hess (rbh27) now if you have an exam conflict. Specify your entire exam schedule (course numbers/contacts and the exam times). We must have this information by Monday 11/23.

A fair die is…

```
classdef Die < handle
 properties (Access=private)
  sides=6;
  top
 end
 methods
  function D = Die(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
 end
 methods (Access=private)
  function setTop(…)  …
 end
end
```

What about a trick die?

Separate classes—each has its own members

```
classdef Die < handle
 properties (Access=private)
  sides=6;
  top
 end
 methods
  function D = Die(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
 end
 methods (Access=private)
  function setTop(…)  …
 end
end
```

```
classdef TrickDie < handle
 properties (Access=private)
  sides=6;
  top
  favoredFace
  weight=1;
 end
 methods
  function D = TrickDie(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
  function f = getFavoredFace(…) …
  function w = getWeight(…)  …
 end
 methods (Access=private)
  function setTop(…)
 end
end
```

Separate classes—each has its own members

```
classdef Die < handle
 properties (Access=private)
  sides=6;
  top
 end
 methods
  function D = Die(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
 end
 methods (Access=private)
  function setTop(…)  …
 end
end
```

```
classdef TrickDie < handle
 properties (Access=private)
  sides=6;
  top
  favoredFace
  weight=1;
 end
 methods
  function D = TrickDie(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
  function f = getFavoredFace(…) …
  function w = getWeight(…)  …
 end
 methods (Access=private)
  function setTop(…)
 end
end
```

Can we get all the functionality of Die in TrickDie without re-writing all the Die components in class TrickDie?

```
classdef Die < handle
 properties (Access=private)
  sides=6;
  top
 end
 methods
  function D = Die(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
 end
 methods (Access=private)
  function setTop(…)  …
 end
end
```

```
classdef TrickDie < handle
```

"Inherit" the components of class Die

```
 properties (Access=private)
  favoredFace
  weight=1;
 end
 methods
  function D = TrickDie(…)  …
  function f =getFavoredFace(…) …
  function w = getWeight(…)  …
 end
end
```

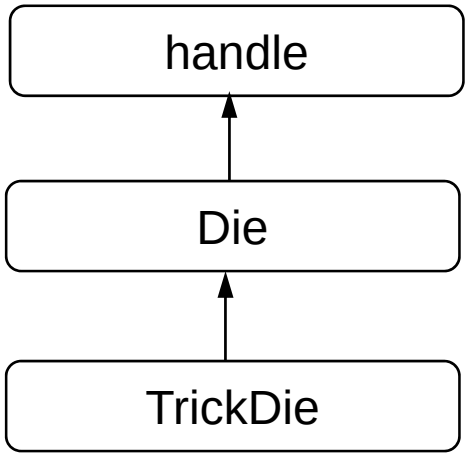
Yes! Make TrickDie a subclass of Die

```
classdef Die < handle
 properties (Access=private)
  sides=6;
  top
 end
 methods
  function D = Die(…)  …
  function roll(…)  …
  function disp(…)  …
  function s = getSides(…)  …
  function t = getTop(…)  …
 end
 methods (Access=protected)
  function setTop(…)  …
 end
end
```

```
classdef TrickDie < Die

 properties (Access=private)
  favoredFace
  weight=1;
 end

 methods
  function D = TrickDie(…)  …
  function f=getFavoredFace(…)…
  function w = getWeight(…)  …
 end

end
```

Inheritance

Inheritance relationships are shown in a *class diagram*, with the arrow pointing to the parent class



An ***is-a*** relationship: the child ***is a*** more specific version of the parent. Eg., a trick die *is a* die.

Multiple inheritance: can have multiple parents ← e.g., Matlab

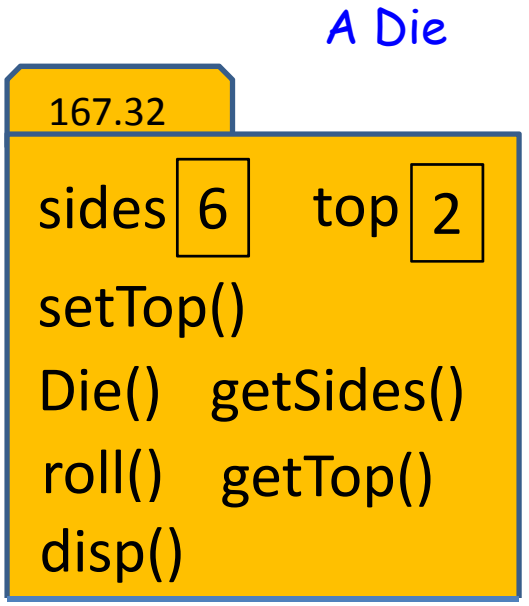
Single inheritance: can have one parent only ← e.g., Java

Inheritance

- Allows programmer to *derive* a class from an existing one
- Existing class is called the *parent class*, or *superclass*
- Derived class is called the *child class* or *subclass*
- The child class *inherits* the (public and protected) members defined for the parent class
- Inherited trait can be *accessed as though it was **locally** defined*

Which components get "inherited"?

- public components get inherited
- private components exist in object of child class, but cannot be directly accessed in child class ⇒ we say they are not inherited
- Note the difference between inheritance and existence!



Which components get "inherited"?

- public components get inherited
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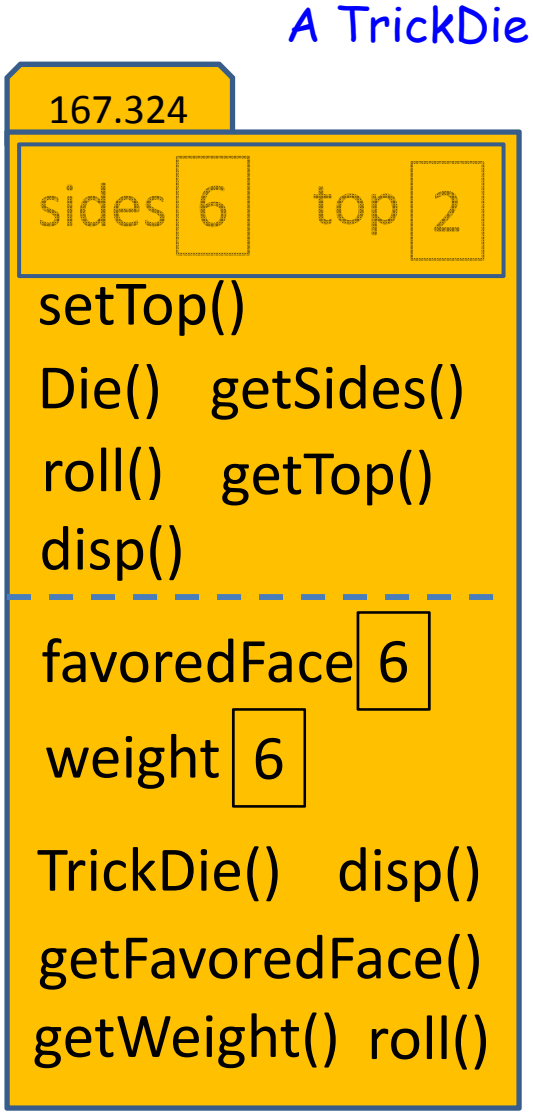
- Note the difference between inheritance and existence!



`protected` attribute

- Attributes dictate which members get inherited

- **`private`**
  - Not inherited, can be *accessed* by local class only
- **`public`**
  - Inherited, can be *accessed* by all classes
- **`protected`**
  - Inherited, can be *accessed* by subclasses

- *Access*: access as though defined locally
- All members from a superclass *exist* in the subclass, but the **`private`** ones cannot be *accessed* directly—can be accessed through inherited (public or protected) methods

Let's play with dice– **`Dies`** and **`TrickDies`**

```
% In Command Window—not class Die or TrickDie
d= Die(6)                 % disp method of Die used
disp(d.top)               % Error; top is private to class Die
d.getTop()
t= TrickDie(2,10,6) % disp method of TrickDie used
disp(t.top)               % Error; top is private to class Die
t.getTop()  % getTop not defined in TrickDie class but
            %    is inherited
d.setTop(5)   % Error; setTop is protected so available
t.setTop(5)    %   only to class Die and its subclasses
```

Constructor: must call the superclass' constructor

- In a subclass' constructor, call the superclass' constructor before assigning values to the subclass' properties.
- Calling the superclass' constructor cannot be conditional: explicitly make one call to superclass' constructor

Syntax

```
classdef Child < Parent

  properties
    propC
  end

  methods

    function obj = Child(argC, argP)

        obj = obj@Parent(argP)

        obj.propC = argC;
    end

    ...
  end

end
```

See constructor in **`TrickDie.m`**

```
td = TrickDie(2, 10, 6);
disp(td.sides)
% disp statement is incorrect because
```

A. Property sides is private.

B. Property sides does not exist in the TrickDie object.

C. Both a, b apply

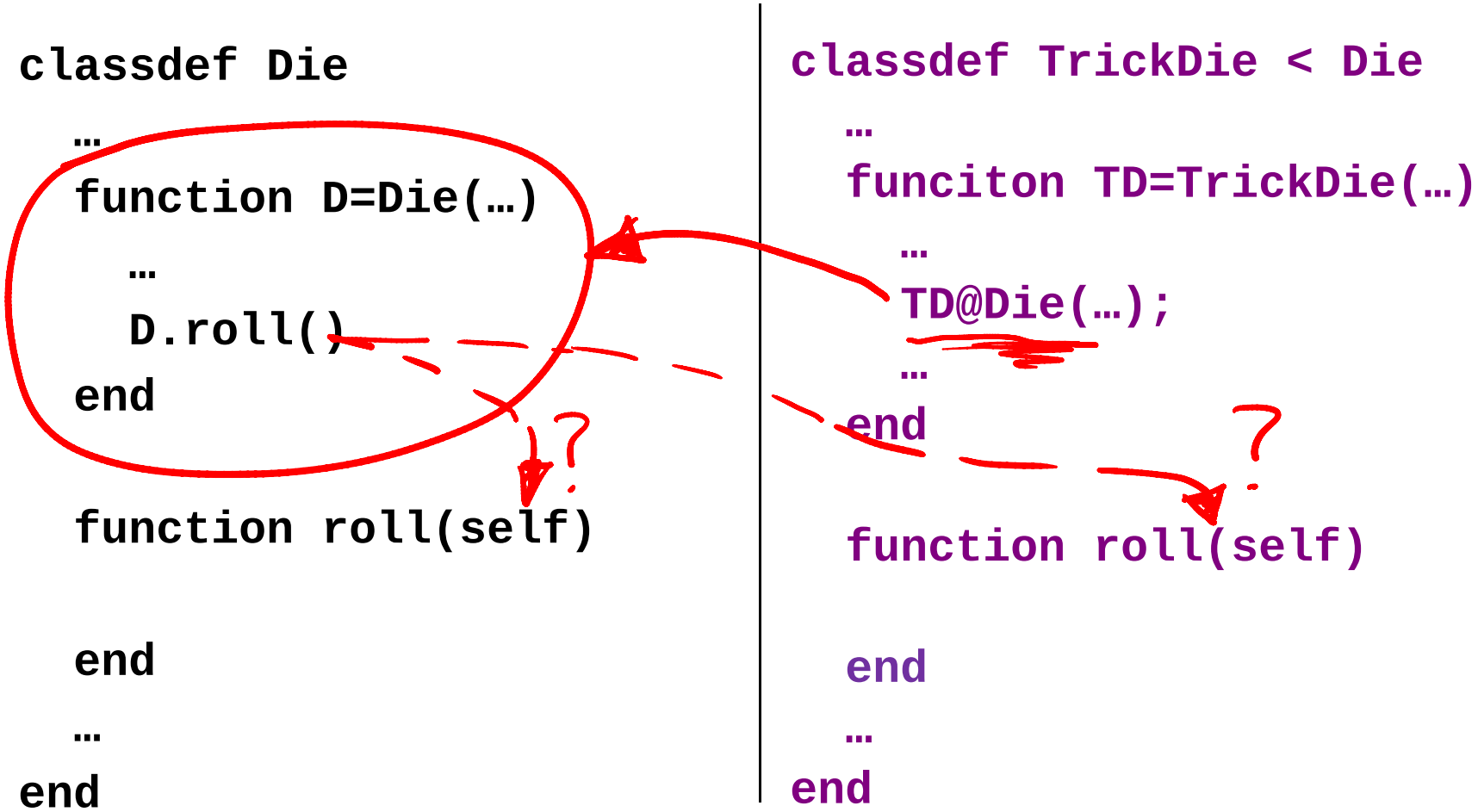
Overriding methods

- Subclass can *override* definition of inherited method
- New method in subclass has the same name (but has different method body)

See method **`roll`** in **`TrickDie.m`**

Overridden methods: which version gets invoked?

To create a TrickDie: call the TrickDie constructor, which calls the Die constructor, which calls the roll method. Which roll method gets invoked?



Overriding methods

- Subclass can *override* definition of inherited method
- New method in subclass has the same name (but has different method body)
- Which method gets used??

  *The **object** that is used to invoke a method determines which version is used*
- Since a TrickDie object is calling method `roll`, the TrickDie's version of `roll` is executed
- In other words, the method most specific to the type (class) of the object is used

Accessing superclass' version of a method

- Subclass can override superclass' methods
- Subclass can access superclass' version of the method

Syntax

```
classdef Child < Parent

 properties
  propC
 end

 methods
  …

  function x= method(arg)

      y= method@Parent(arg);

      x = … y … ;
  end

  …
 end
end
```

See method **`disp`** in **`TrickDie.m`**

Important ideas in inheritance

- Keep common features as high in the hierarchy as reasonably possible
- Use the superclass' features as much as possible
- "Inherited" $\Rightarrow$ "can be accessed as though declared locally"

  (`private` member in superclass *exists* in subclasses; they just cannot be accessed directly)
- Inherited features are continually passed down the line

(Cell) array of objects

- A cell array can reference objects of different classes

```
A{1}= Die();
A{2}= TrickDie(2,10);   % OK
```

- A simple array can reference objects of only one single class

```
B(1)= Die();
B(2)= TrickDie(2,10);   % ERROR
```

- (Assignment to B(2) above would work if we define a "convert method" in class TrickDie for converting a TrickDie object to a Die. We won't do this in CS1112.)

End of Matlab OOP in CS1112

OOP is a concept; in different languages it is expressed differently.

In CS (ENGRD) 2110 you will see Java OOP