Stacks

- Assignment 5:
  - Abstract Classes
  - Hierarchy
- Stacks - an Abstract Data Type
  - Class interface
  - Polymorphism
  - Use of List as representation of Stacks
  - Pop versus Peek

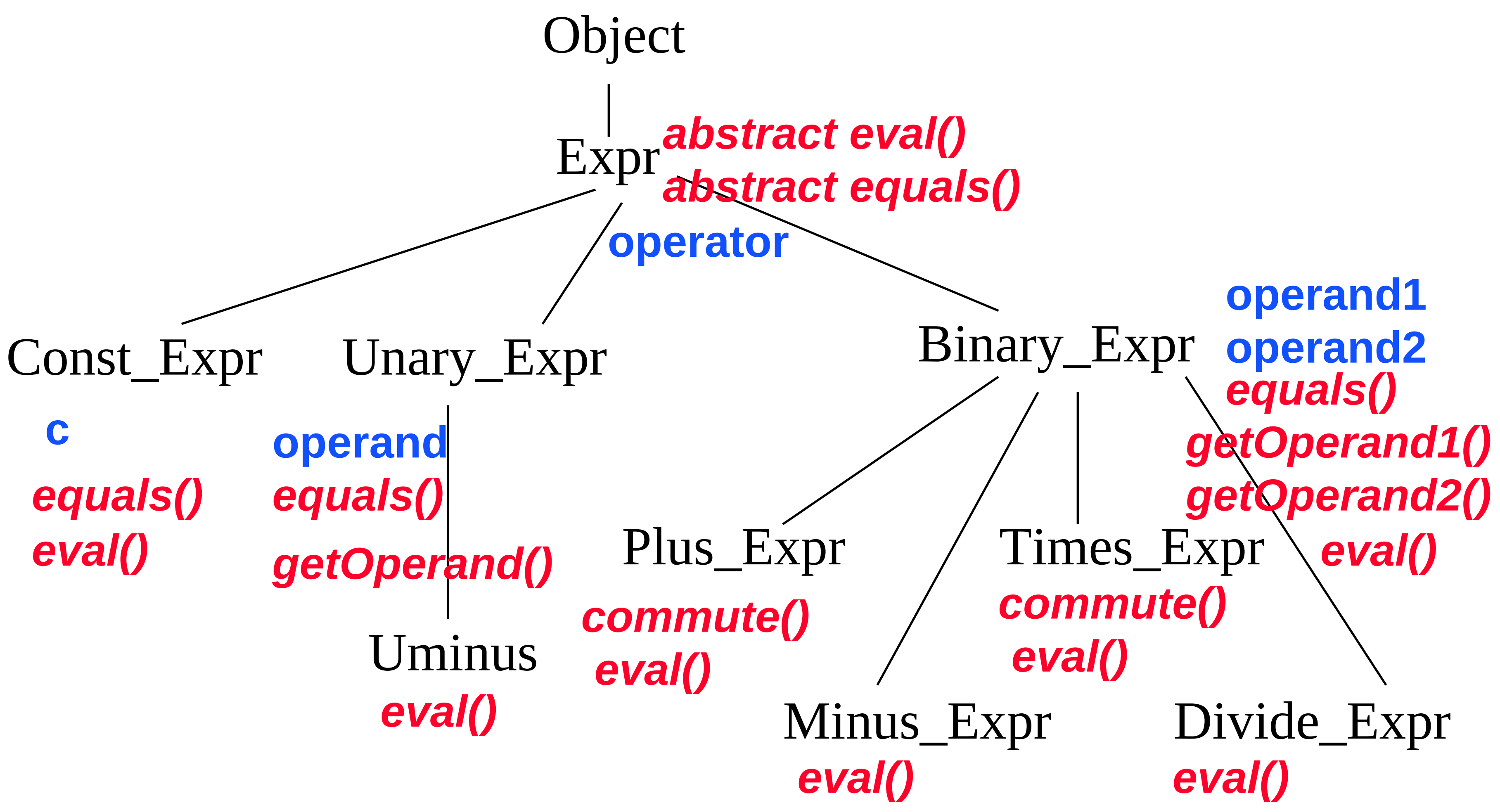
Abstract Classes

- Useful when you want to define only part of an implementation
- Abstract classes
  - Abstract methods are signatures of promised methods to be provided in subclasses of the abstract class
    - Can provide these through definition or inheritance
  - No objects can be created
    - Because abstract method implementations don’t exist

Abstract Classes

- Can define methods (and implementations) in an abstract class which can be inherited by subclasses
- Can also contain instance variables to be inherited by subclasses
- Examples in Assignment 5: Expr, Unary_Expr, Binary_Expr

Assignment 5: Expressions



Expr Class Interface

```
public abstract class Expr extends Object
{ private String operator;

  Expr(String s)//constructor
  { operator = s; }

  abstract boolean equals(Expr e);
  abstract int eval();
}
```

Unary_Expr Class Interface

```
public abstract class Unary_Expr
{ private Expr operand

  Unary_Expr(Expr e, String s)
  {  super(s);
     operand = e;
  }
  public Expr getOperand() {.....}
  public String toString() {.....}
  public boolean equals(Expr other) {...}
}
```

Super

- Super acts as a reference to an object as an instance of its superclass
- The reference to super in the Unary_Expr class constructor, means call the Expr constructor with argument String s.
  - Implicitly, when a subclass object is created, the constructor of the superclass is called before anything else is done in the subclass constructor
  - If arguments are needed, super(args) is used to call this constructor.

Binary_Expr Class Interface

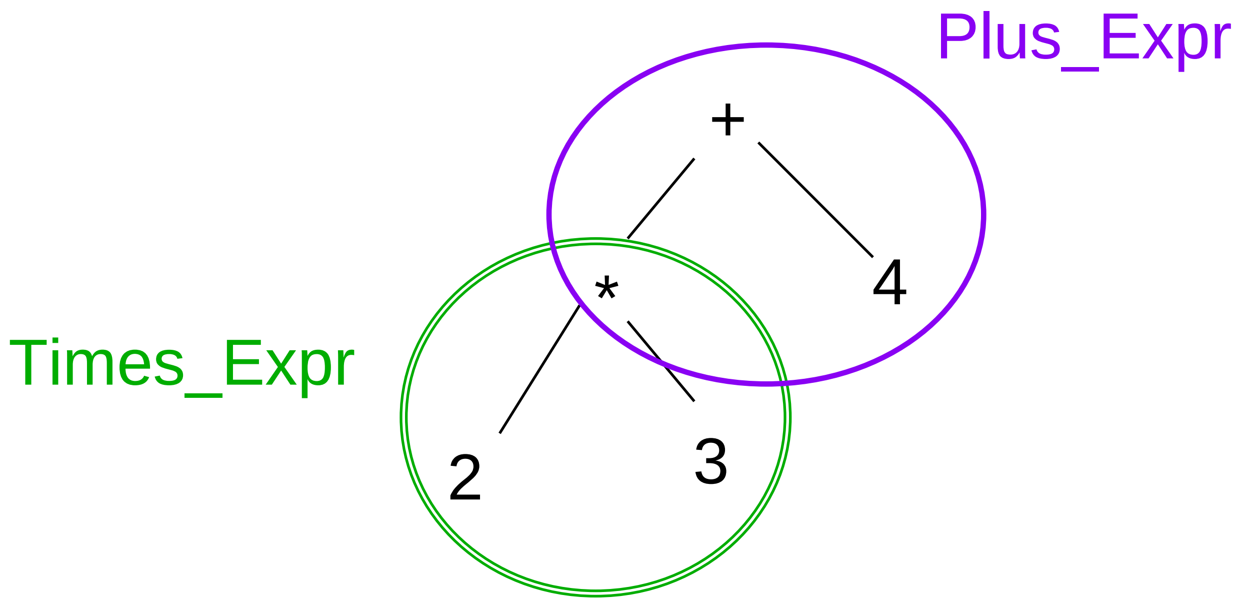
```
public abstract class Binary_Expr extends
  Expr
{ private Expr operand1, operand2;
  Binary_Expr(Expr e1, Expr e2, String s)
  { super(s);
    operand1 = e1;
    operand2 = e2;
  }
  public Expr getFirstOperand() {...}
  public Expr getSecondOperand() {...}
  public String toString() {...}
  public boolean equals(Expr other) {...}
}
```

“Recursive” Objects

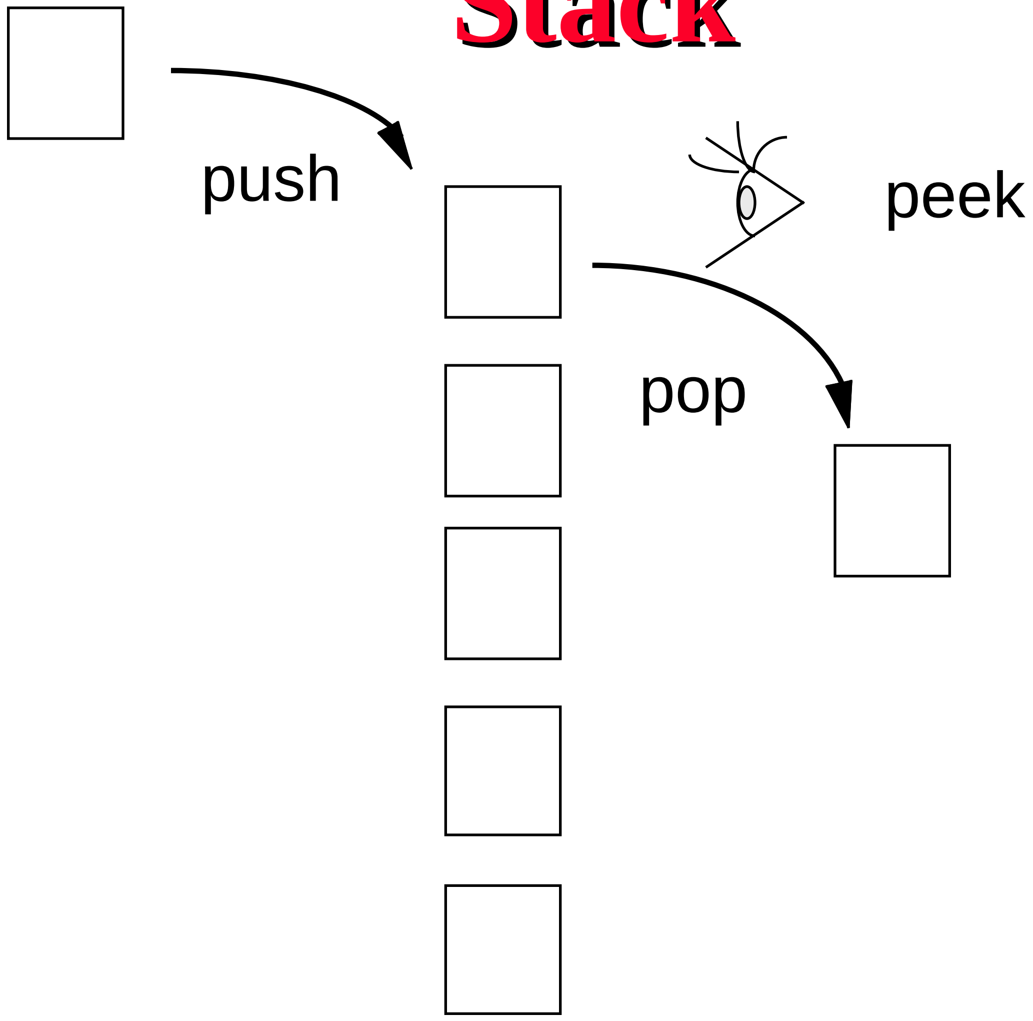
- Operands within an expression are themselves expressions
  - 2*3+4 is a Plus_Expr constructed from Times_Expr e1, Const_Expr c1, and String “+”
    - where e1 is Times_Expr(2,3,”*”) and c1 is Const_Expr(4)
- Expr objects with instance variables that are other Expr objects

Expr Objects

- **Expression "trees"**
  - **FirstOperand, SecondOperand**



Stack



Stacks

- **Stacks in real-life**
  - **Redial button on telephone - calls the last number dialed**
  - ***history* (his) command in Unix (!! executes your last typed command)**
  - **Job layoffs of people with least seniority**
  - **Pile of plates in restaurant**

Stack Class Interface

- Instance variables:
  - private List top
  - private int length
- Instance methods:
- public Stack() //constructor
- public int getLength() //# of elements
- public boolean empty()
- public String toString()
- public Enumeration getEnumeration()

Stack Methods

```
public Stack() {//empty stack is top as null List
  top = null;
  length = 0;
}
public int getLength(){//observer
  return length;
}
public boolean empty(){//true if length!=0
  return (length == 0);
}
```

Stack Interface

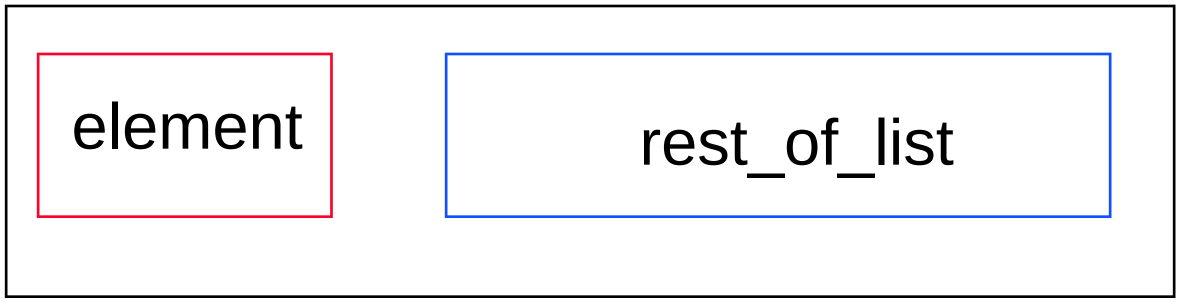
- public void push (Object newItem)
  - adds element newItem to stack
  - polymorphic abstract data type (ADT)
- public Object pop() throws StackException
  - removes element from Stack and returns it
  - polymorphic
- public Object peek() throws StackException
  - allows examination of top element on Stack without removing it
  - polymorphic

Stack Class: How to build?

- How to represent Stacks?
  - Use List class (first element, rest_of_list) to hold elements in a stack
- Potential special cases
  - Pop off or peek at an empty stack
  - Push onto an empty stack
  - Both can be handled by encoding the empty stack as top == null and length == 0
- Can use length== 0 to check for empty stack

Lists

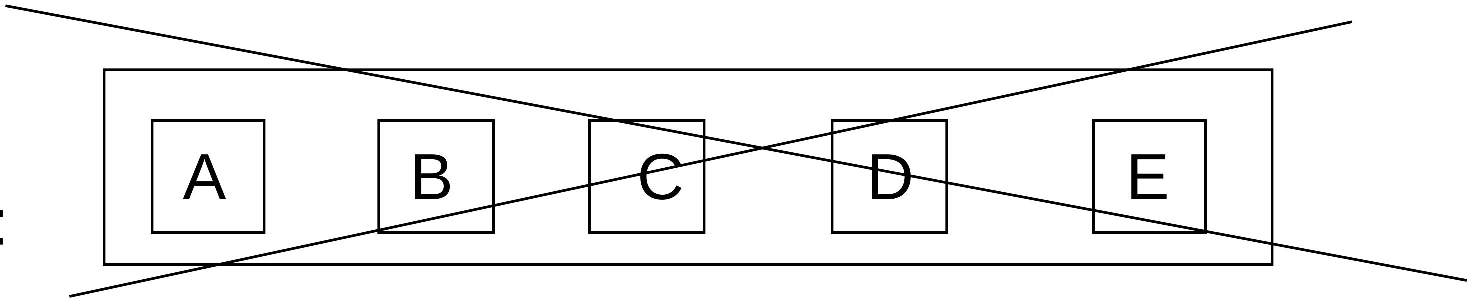
- A list is a sequence of objects
  - Bad view for thinking about operations on lists
- A list is a pair, a first element and a rest_of_list, which is a sublist



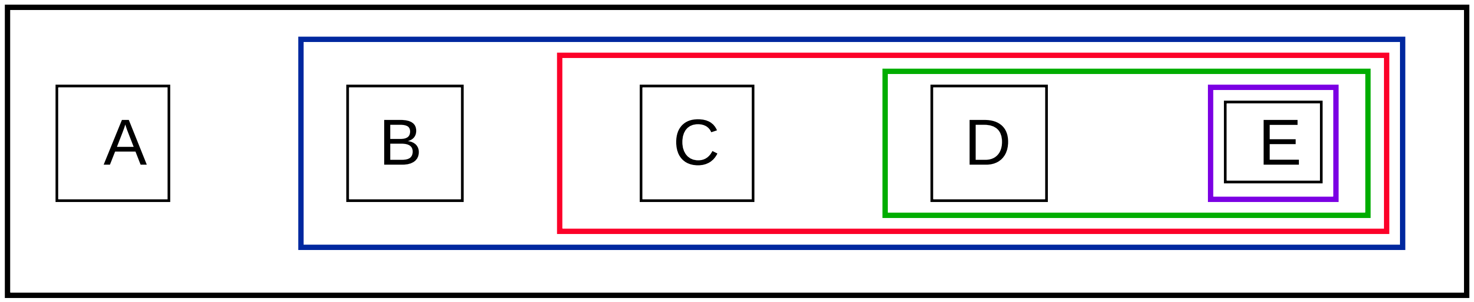
Lists

cs111.util.List.*

not this:



Preferable



Details here are hidden by List class implementation!

Lists

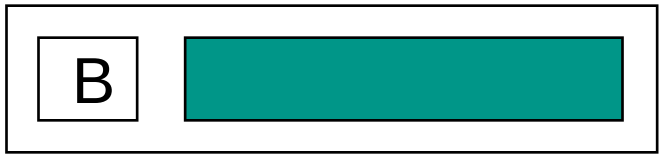
```
public class List extends Object{
  protected Object info;//field is accessible only
  protected List subList;//by classes in package
                //means field is private to package
public List{
  info = null;
  subList = null;
}
public List (Object element, List oldList){
  info = element;
  subList = oldList;
}
```

(Note: design in cs111.util.* differs slightly from this)

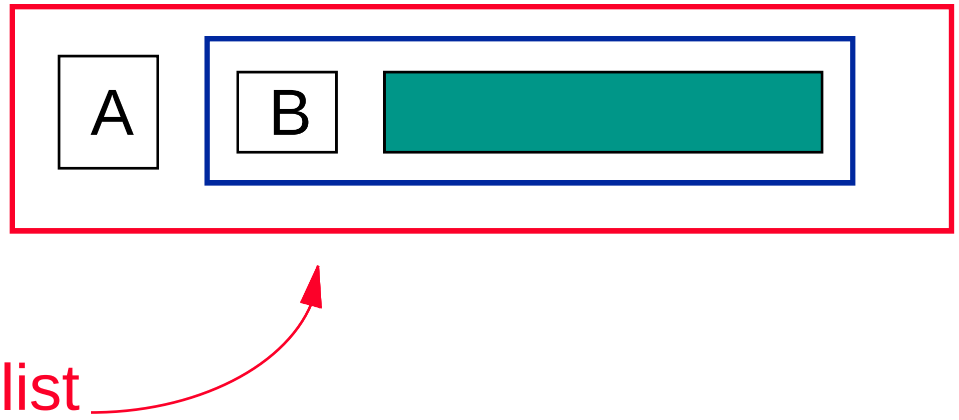
List Construction

element: A

oldList:



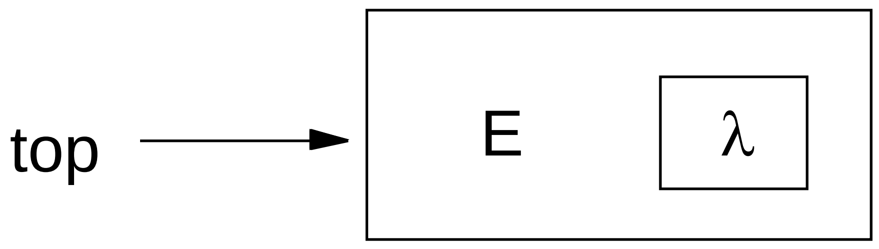
result:



Push onto empty stack

Initially,
top is null
length is 0

Perform push(E)



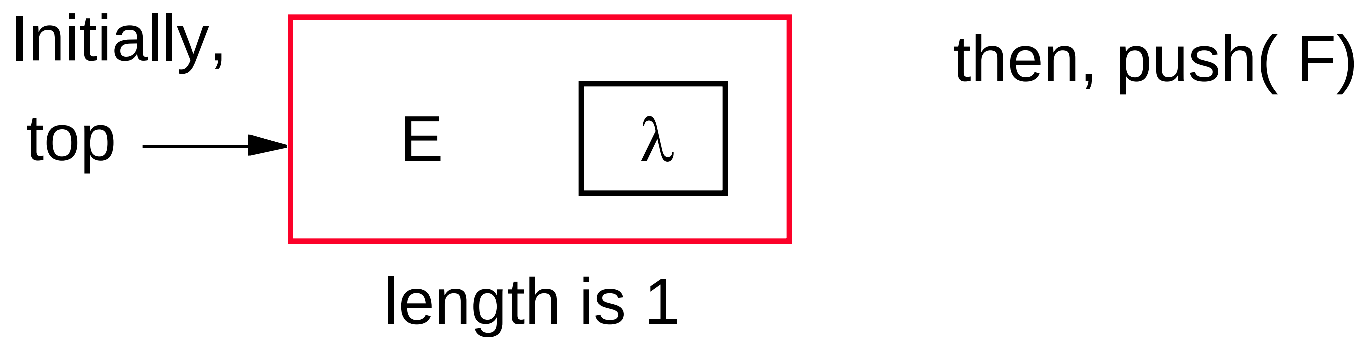
length is 1

```
List nl = new List(newItem, top)
top = nl;
```

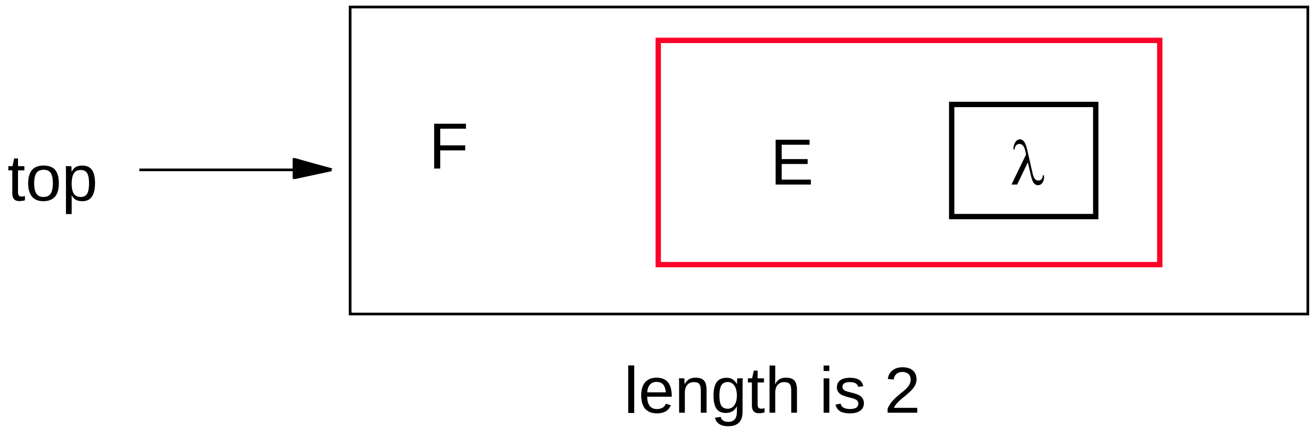
Push Method

```
//create new List with old List as subList and
//newItem as first element
public void push(Object newItem){
  List nl = new List(newItem, top);
  top = nl;
  length++;
}
```

Push onto non-empty Stack



then, push(F)



Pop Method

```
public Object pop() throws StackException{
  if (empty()) throw new StackException
      (“Attempt to pop from empty Stack”);
  Object ret = top.info;
  top = top.subList;
  length--;
  return ret;
}
```

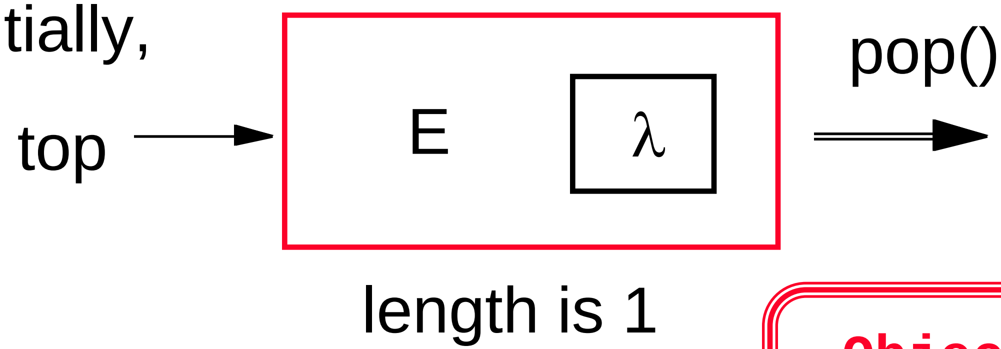
Pop off empty stack

Initially,
top is null
length is 0

empty() yields true

Pop off non-empty stack

Initially,



return E
top is null
length is 0

```
Object ret = top.info;
top = top.subList;
length--;
return ret;
```

User-defined Exception

```
public class StackException extends Exception{
  String msg;
  StackException (String str){
      msg = str;
  }
}
```

• Define as extension of built-in class Exception
• Pass StackException object with private String instance variable to exception handler for possible printing
• No handler in Stack class means user of Stack class can handle or pass along to default handler in class Object

Pop( ) versus Peek( )

```
public Object pop() throws StackException{
  if (empty()) throw new StackException
      (“Attempt to pop from empty Stack”);
  Object ret = top.info;
  top = top.subList;
  length--;
  return ret;
}
public Object peek() throws StackException{
  if (empty()) throw new StackException
      (“Attempt to peek at an empty Stack”);
  return top.info;
}
```

toString Method

```
//uses toString() method in Lists to return contents
//of Stack
public String toString(){
  String ret = “Stack length is “ + length + “\n”;
  return ret + “stack is:  “ + top.toString;
}
```