Final Examples

Announcements

Trees

Tree-Structured Data

Tree-Structured Data

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def tree(label, branches=[]):
    return [label] + list(branches)

def label(t):
    return t[0]

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def is_leaf(t):
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Tree processing often involves recursive calls on subtrees

Tree Processing

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than all labels of their ancestor nodes. (Assume the root label is always larger than all of its ancestors, since it has none.)

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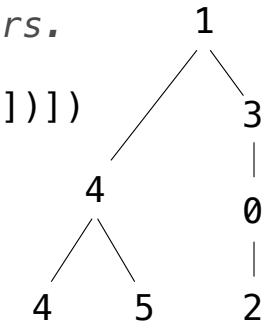

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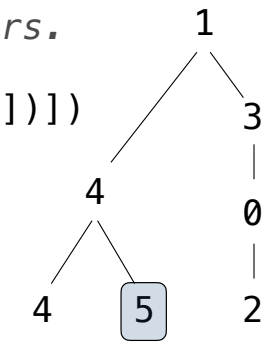

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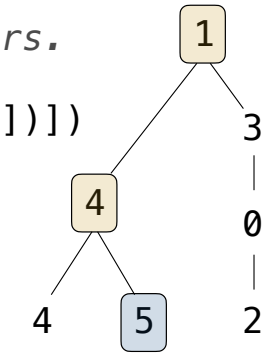

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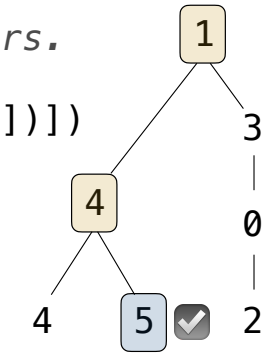

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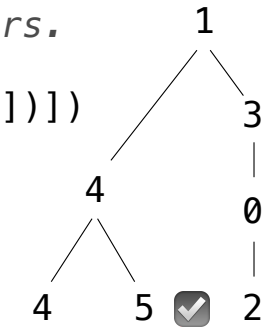

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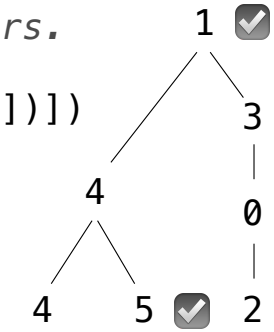

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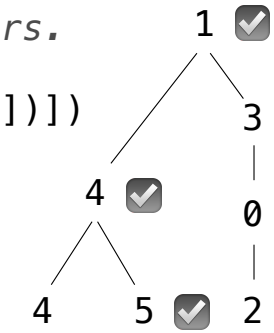

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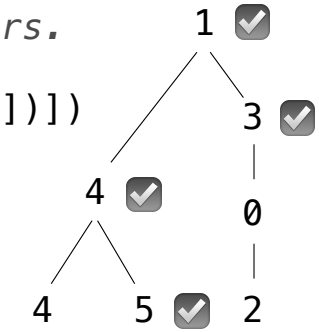

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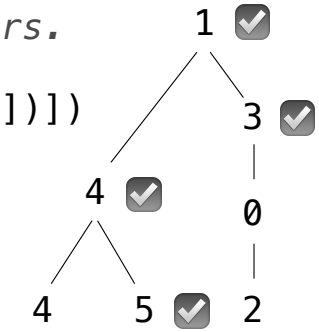


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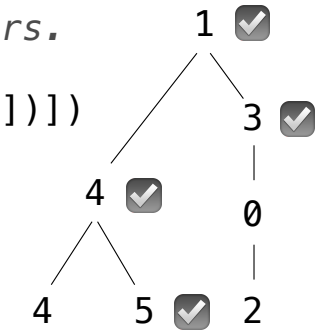


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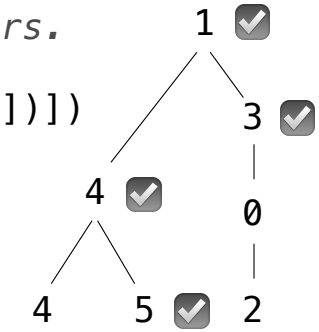


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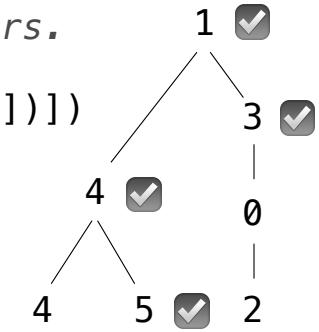


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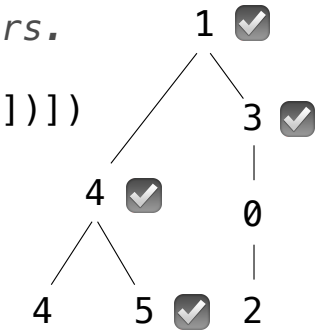


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Somehow track a list of ancestors

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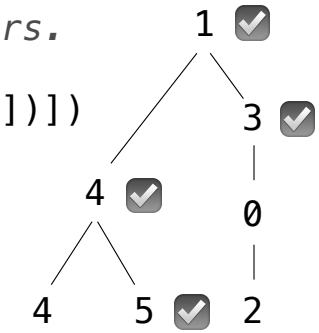


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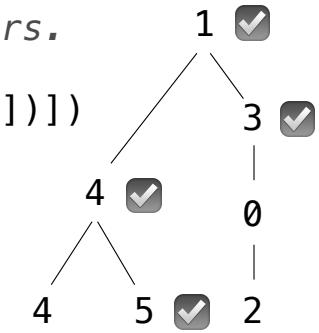


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Somehow track the largest ancestor

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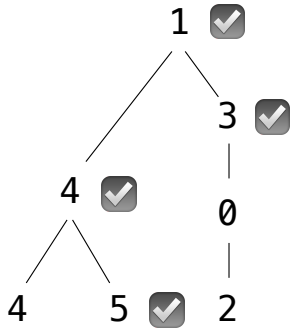

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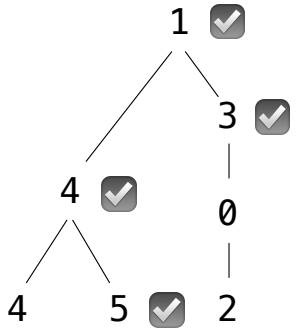

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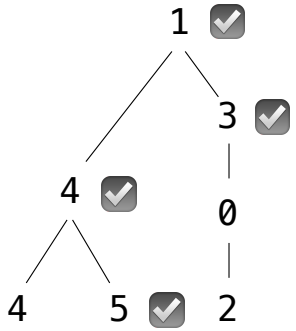

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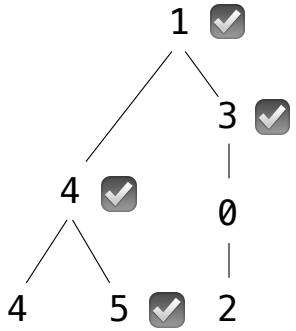

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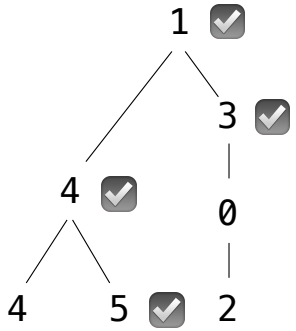
A node *max_ancestor*

a.label > x

node.label > max_ancestors



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    4
    """
    def f(a, x):
        if _____________________:
            return 1 + _____________________
        else:
            return _____________________
    return f(t,          )
```

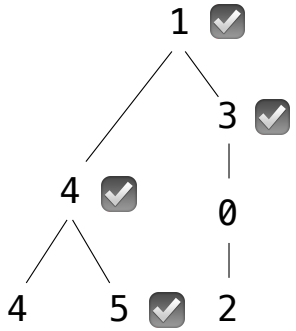
A node

max_ancestor

Somehow track the largest ancestor

a.label > x

node.label > max_ancestors



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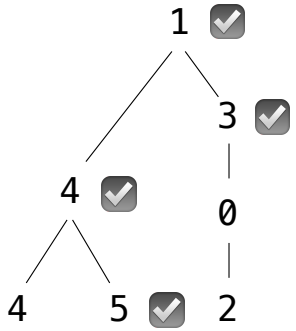
Some initial value for the largest ancestor so far...



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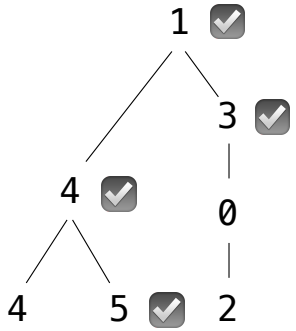
Somehow increment the total count

Some initial value for the largest ancestor so far...



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A node

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Somehow track the largest ancestor

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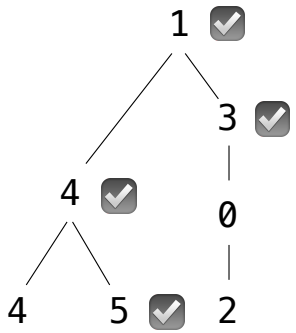
sum([f(b, a.label) for b in a.branches])

Somehow increment the total count

f(t,)

Some initial value for the largest ancestor so far...



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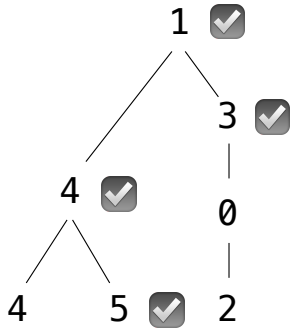

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Root label is always larger than its ancestors

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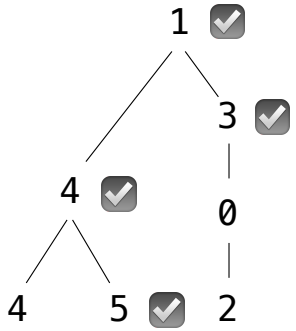

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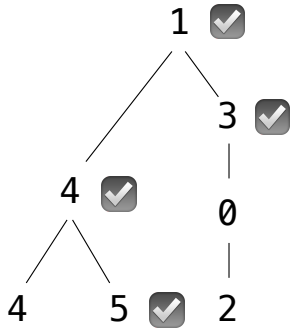

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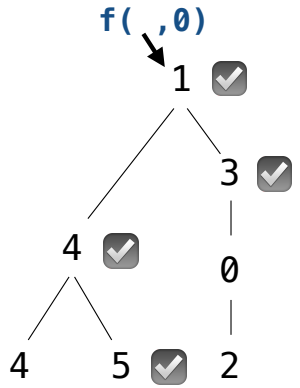

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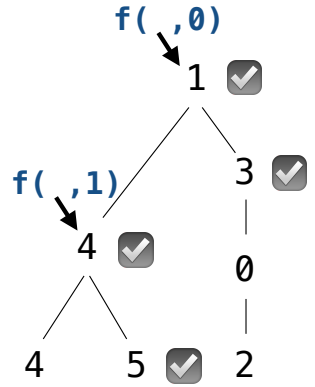

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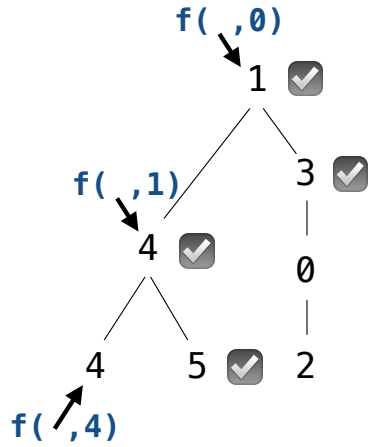

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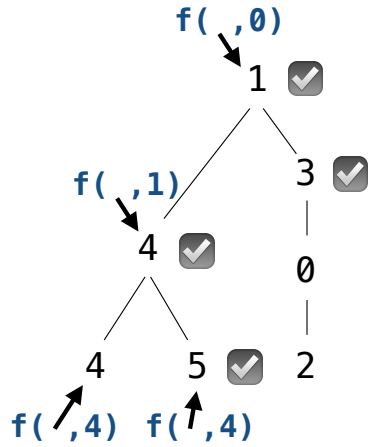

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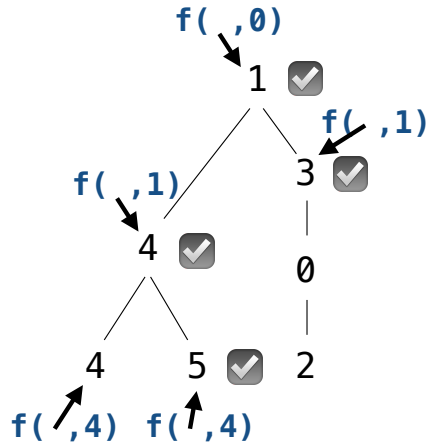

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Somehow track the largest ancestor

node.label > max_ancestors

a.label > x

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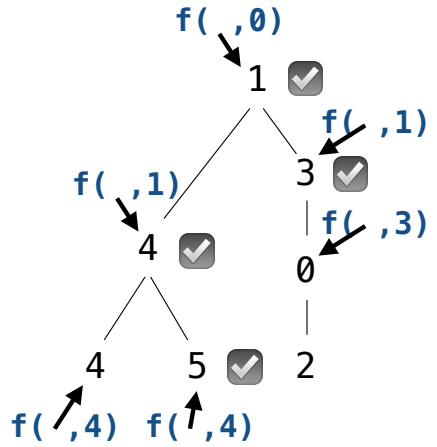

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Somehow track the largest ancestor

A node — max_ancestor

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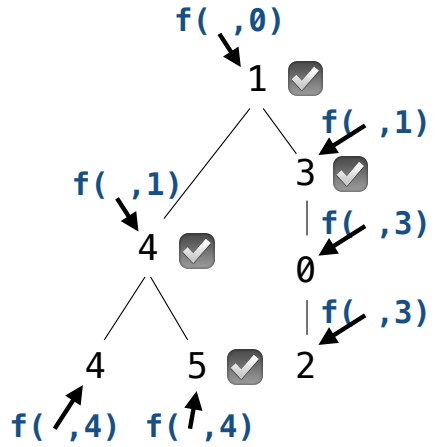

Recursive Accumulation

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

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def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors."""
    n = [0]

    def f(a, x):

        if _____________________:

           _____________________

        _____________________:

            f(_____________________)

    _____________________________

    return n[0]
```

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Somehow track the largest ancestor

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```

Somehow track the largest ancestor

node.label > max_ancestors

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Somehow increment the total count

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Somehow track the largest ancestor

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Somehow increment the total count

Root label is always larger than its ancestors

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def bigs(t):
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    n = [0]

    def f(a, x):
        if a.label > x:
            n[0] += 1

        f(_____)

    f(_____)

    return n[0]
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Somehow track the largest ancestor

node.label > max_ancestors

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        f(t, t.label - 1)

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```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors."""
    n = [0]

    def f(a, x):                    # Somehow track the largest ancestor
        if a.label > x:             # node.label > max_ancestors
            n[0] += 1               # Somehow increment the total count
        for b in a.branches:
            f(b, max(a.label, x))
    f(t, t.label - 1)               # Root label is always larger than its ancestors

    return n[0]
```

Designing Functions

How to Design Programs

https://htdp.org/2018-01-06/Book/

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From Problem Analysis to Data Definitions

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Fill in the gaps in the function template. Exploit the purpose statement and the examples.

https://htdp.org/2018-01-06/Book/

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From Problem Analysis to Data Definitions
Identify the information that must be represented and how it is represented in the chosen programming language. Formulate data definitions and illustrate them with examples.

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State what kind of data the desired function consumes and produces. Formulate a concise answer to the question *what* the function computes. Define a stub that lives up to the signature.

Functional Examples
Work through examples that illustrate the function's purpose.

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Applying the Design Process

Designing a Function

Implement **smalls**, which takes a Tree instance t containing integer labels. It returns the non-leaf nodes in t whose labels are smaller than any labels of their descendant nodes.

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def smalls(t):
    """Return the non-leaf nodes in t that are smaller than all their descendants.

    >>> a = Tree(1, [Tree(2, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(6)])])])
    >>> sorted([t.label for t in smalls(a)])
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    """
    result = []
    def process(t):









    process(t)
    return result
```

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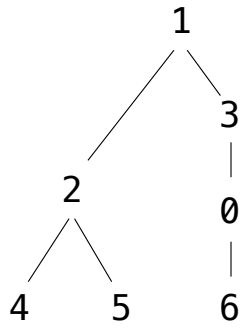

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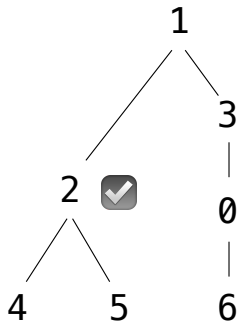

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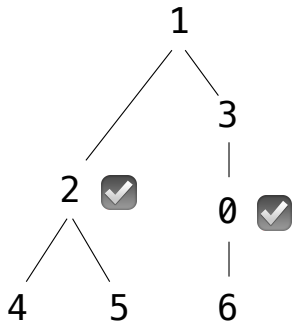

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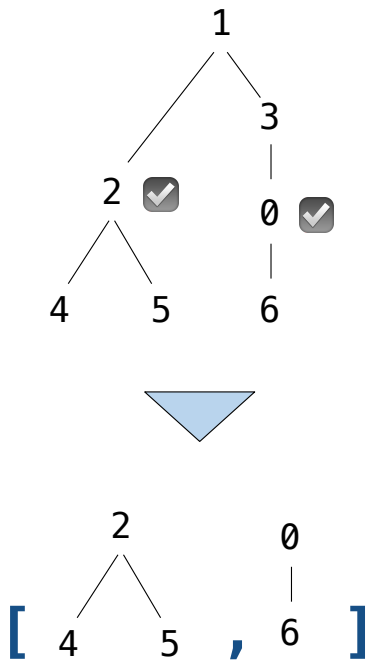

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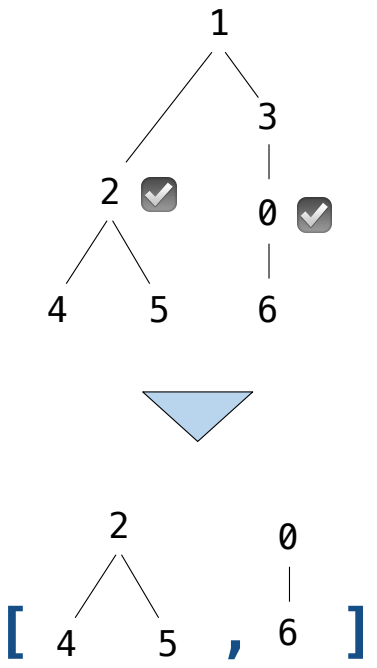
    """
    result = []
    def process(t):
        process(t)
    return result
```

Signature: Tree -> number



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    """
    result = []
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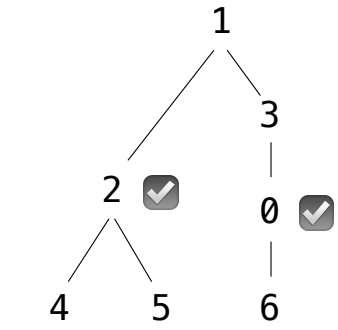
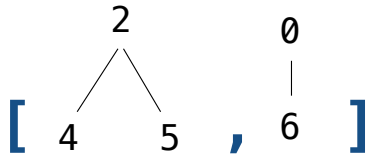
```

Signature: Tree -> List of Trees

Signature: Tree -> number

"Find smallest label in t & maybe add t to result"





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    """
    result = []
    def process(t):
        if t.is_leaf():
            return t.label
        else:

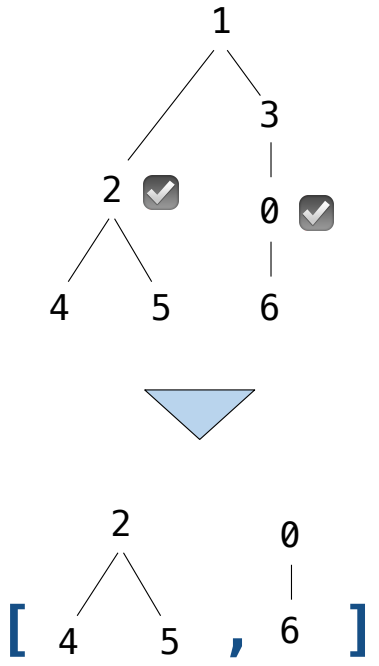


            return min(...)
    process(t)
    return result
```

Signature: Tree -> List of Trees

Signature: Tree -> number

"Find smallest label in t & maybe add t to result"



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```
def smalls(t):
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    >>> sorted([t.label for t in smalls(a)])
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    """
    result = []
    def process(t):
        if t.is_leaf():
            return ____________________________________________
        else:
            smallest = ____________________________________________
            if ____________________________________________:
                ____________________________________________
            return min(smallest, t.label)
    process(t)
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```

Signature: Tree -> List of Trees

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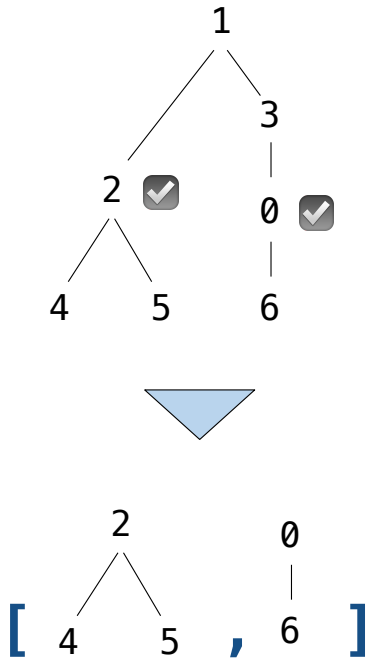
"Find smallest label in t & maybe add t to result"



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Signature: Tree -> List of Trees

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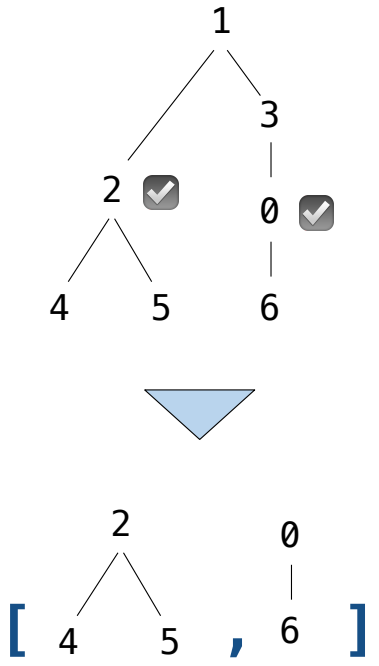
"Find smallest label in t & maybe add t to result"

t.label



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```

Signature: Tree -> List of Trees

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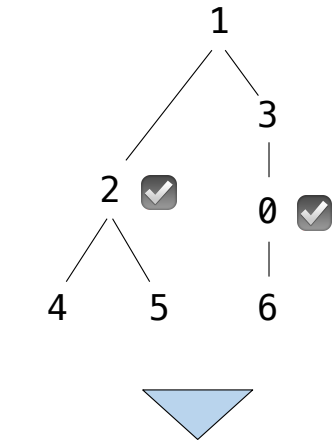
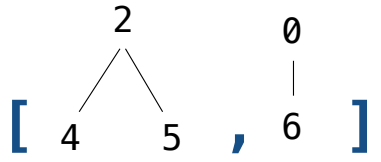
"Find smallest label in t & maybe add t to result"

t.label

smallest label in a branch of t





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Signature: Tree -> List of Trees

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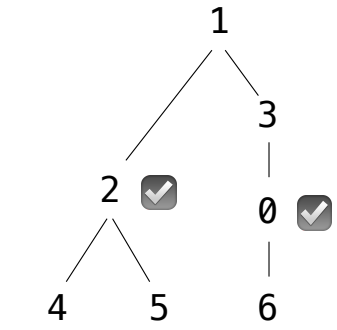
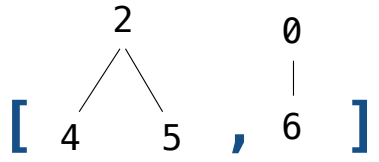
t.label

t.label < smallest

smallest label in a branch of t





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Signature: Tree -> List of Trees

Signature: Tree -> number

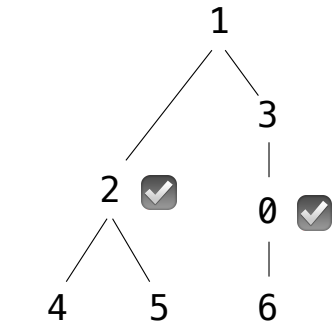
"Find smallest label in t & maybe add t to result"

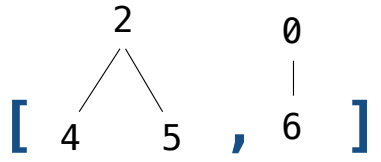
t.label

smallest label in a branch of t

t.label < smallest

result.append( )





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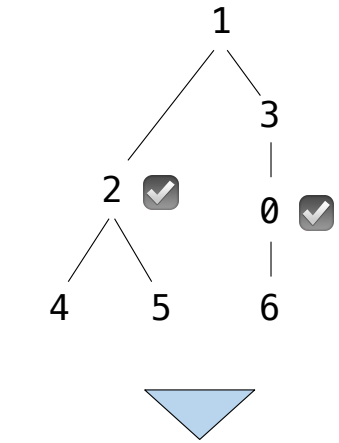

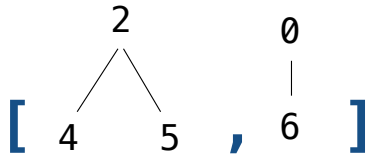

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"Find smallest label in t & maybe add t to result"

t.label

min([process(b) for b in t.branches])

t.label < smallest

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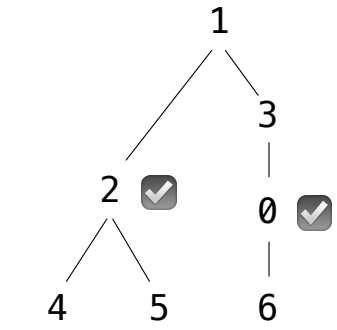
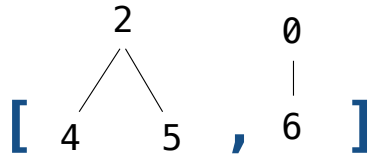
smallest label in a branch of t





Interpreters

Interpreter Analysis

What expressions are passed to scheme_eval when evaluating the following expressions?

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(define x (+ 1 2))
```

```
(define (f y) (+ x y))
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```
(f (if (> 3 2) 4 5))
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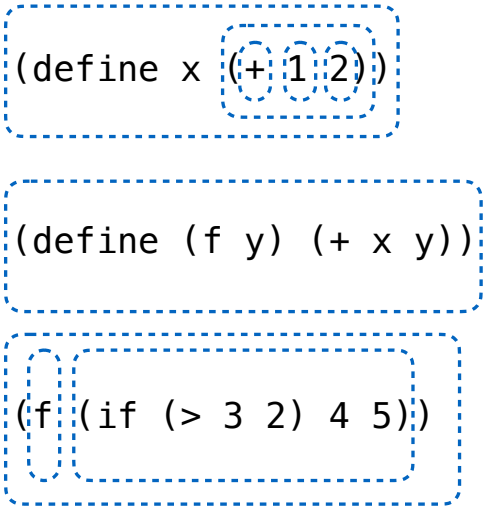

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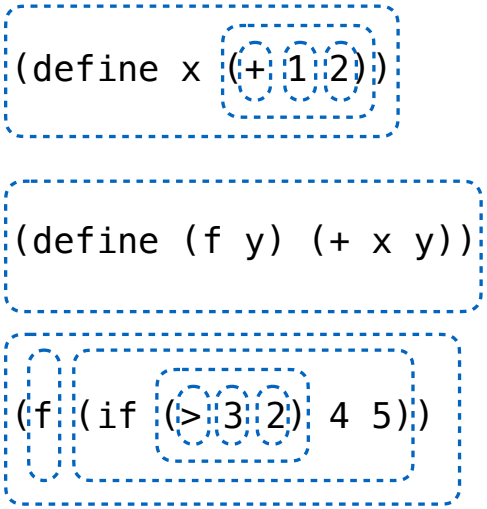

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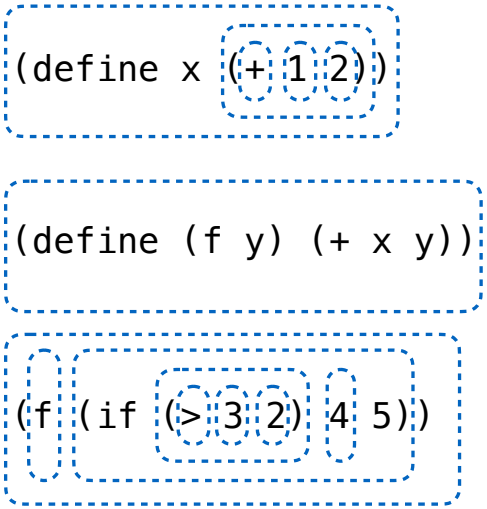

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