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BALANCED BINARY TREES (22/22 points)

A binary tree `t`, of the `'a bt` type given in the prelude, is either an empty tree, or the root of a tree with a value and two children subtrees.

1. Write a function `height : 'a bt -> int` that computes the height of a tree.
2. A tree is *balanced* if, for all internal node `n`, its two subtrees have the same height. Write a function `balanced : 'a bt -> bool` that tells if a tree is balanced.

THE GIVEN PRELUDE

```
type 'a bt =
  | Empty
  | Node of 'a bt * 'a * 'a bt ;;
```

YOUR OCAML ENVIRONMENT

```
let rec height t = match t with
  | Empty -> 0
  | Node (l, _, r) ->
      let l1 = height l in
      let l2 = height r in
      if l1 < l2 then l2 + 1 else l1 + 1
;;

let rec balanced t  = match t with
  | Empty -> true
  | Node (l, _, r) ->
      if height l = height r then
        true && balanced l && balanced r
      else false
;;

```

Evaluate >

Switch >>

Typechecl

Reset Templ

Full-screen |

Check & Sa

Exercise complete (click for details) 22 pts

v Exercise 1: height Completed, 11 pts

Found `height` with compatible type.

```
Computing
  height
    (Node
      (Node (Node (Node (Empty, 4, Empty), -5, Node (Empty, 0, Empty)), 2,
        Node (Empty, 3, Empty)),
      2, Node (Empty, -5, Node (Empty, 4, Node (Empty, -5, Empty)))))
```

Correct value `4` 1 pt

Computing `height (Node (Empty, 4, Empty))`

Correct value `1` 1 pt

```
Computing
  height
    (Node (Node (Empty, 3, Node (Empty, 0, Empty)), -4,
      Node (Empty, -4, Empty)))
```

Correct value `3` 1 pt

```
Computing
  height
    (Node
      (Node
        (Node (Node (Node (Empty, 3, Empty), -2, Node (Empty, -1, Empty)), -2,
          Node (Node (Empty, 2, Empty), -3, Node (Empty, -4, Empty))),
        -4,
        Node (Node (Node (Empty, -1, Empty), -4, Node (Empty, -1, Empty)), 1,
         Node (Node (Empty, -1, Empty), 1, Node (Empty, -3, Empty)))),
      -5,
      Node
       (Node (Node (Node (Empty, 3, Empty), 0, Node (Empty, -5, Empty)), 1,
Correct value 5                                                    1 pt
Computing
  height
    (Node (Empty, -2,
      Node
       (Node (Node (Empty, 1, Empty), 1,
         Node (Node (Empty, 4, Empty), 4, Node (Empty, 2, Empty))),
       -3, Empty)))
Correct value 5                                                    1 pt
Found height with compatible type.
Computing height Empty
Correct value 0                                                    1 pt
Computing
  height
    (Node
      (Node
        (Node (Node (Node (Empty, 'n', Empty), 's', Node (Empty, 'w', Empty)),
          'o', Node (Node (Empty, 'l', Empty), 'r', Node (Empty, 'q', Empty))),
        'a',
        Node (Node (Node (Empty, 'd', Empty), 'v', Node (Empty, 'z', Empty)),
         'f', Node (Node (Empty, 'z', Empty), 'n', Node (Empty, 'p', Empty)))),
      'w',
      Node
       (Node (Node (Node (Empty, 'c', Empty), 'y', Node (Empty, 'n', Empty)),
         'g', Node (Node (Empty, 'm', Empty), 'p', Node (Empty, 'm', Empty))),
       'u',
       Node (Node (Node (Empty, 'b', Empty), 'm', Node (Empty, 'v', Empty)),
        'w', Node (Node (Empty, 'r', Empty), 'g', Node (Empty, 'r', Empty))))))
Correct value 5                                                    1 pt
Computing
  height
    (Node
      (Node (Node (Empty, 'u', Empty), 'r',
        Node (Node (Empty, 'x', Empty), 'u',
         Node (Node (Empty, 'k', Empty), 'q', Node (Empty, 'u', Empty)))),
      'k',
      Node (Node (Empty, 't', Empty), 'k',
       Node (Empty, 'q', Node (Empty, 'k', Empty)))))
Correct value 5                                                    1 pt
Computing height (Node (Node (Empty, 'g', Empty), 'p', Node (Empty, 'l', Empty)))
Correct value 2                                                    1 pt
Computing
  height
    (Node
      (Node (Node (Node (Empty, 'v', Node (Empty, 'c', Empty)), 'v', Empty),
        'c', Node (Node (Node (Empty, 'f', Empty), 'f', Empty), 'd', Empty)),
      'g',
      Node (Empty, 's',
       Node (Node (Node (Empty, 't', Empty), 'i', Empty), 'v', Empty))))
Correct value 5                                                    1 pt
Computing height (Node (Empty, 'c', Empty))
Correct value 1                                                    1 pt
v Exercise 2: balanced                                 Completed, 11 pts
Found balanced with compatible type.
Computing
  balanced
    (Node (Node (Node (Empty, 1, Empty), 1, Node (Empty, 0, Empty)), -3,
      Node (Node (Empty, 4, Empty), -3, Node (Empty, -1, Empty))))
Correct value true                                                 1 pt
Computing
  balanced
    (Node
      (Node
        (Node (Node (Node (Empty, 1, Empty), -2, Node (Empty, 1, Empty)), 2,
          Node (Empty, 1, Node (Empty, -3, Empty))),
        -5, Empty),
      2,
      Node (Empty, 4,
       Node (Empty, -1, Node (Empty, 3, Node (Empty, 2, Empty))))))
Correct value false                                                1 pt
Computing
  balanced
    (Node (Node (Empty, -3, Empty), 1,
      Node (Empty, 3,
       Node (Node (Empty, 0, Empty), 1,
        Node (Node (Empty, 2, Empty), 0, Empty)))))
Correct value false                                                1 pt
Computing
```

```
Correct value true                                                              1 pt
Computing
  balanced
    (Node (Empty, 1,
      Node (Node (Empty, -1, Node (Empty, 1, Empty)), -5,
       Node (Empty, 4, Node (Node (Empty, -1, Empty), -5, Empty)))))
Correct value false                                                             1 pt
Found balanced with compatible type.
Computing balanced Empty
Correct value true                                                              1 pt
Computing
  balanced
    (Node
      (Node
        (Node (Node (Empty, 'f', Node (Empty, 'e', Empty)), 'o',
          Node (Node (Empty, 'w', Empty), 'p', Node (Empty, 'd', Empty))),
        'q', Empty),
      'f',
      Node
       (Node (Node (Empty, 'b', Node (Empty, 'w', Empty)), 'k',
         Node (Empty, 'v', Empty)),
       'r',
       Node (Node (Node (Empty, 'g', Empty), 'l', Node (Empty, 'z', Empty)),
        'k', Node (Node (Empty, 'z', Empty), 'z', Node (Empty, 'r', Empty))))))
Correct value false                                                             1 pt
Computing
  balanced
    (Node
      (Node (Node (Node (Empty, 'v', Empty), 'z', Node (Empty, 'f', Empty)),
        'o', Node (Node (Empty, 'i', Empty), 'y', Node (Empty, 'c', Empty))),
      'o',
      Node (Node (Node (Empty, 'g', Empty), 'j', Node (Empty, 'p', Empty)),
       'p', Node (Node (Empty, 'v', Empty), 'i', Node (Empty, 'x', Empty)))))
Correct value true                                                              1 pt
Computing
  balanced
    (Node
      (Node (Node (Node (Empty, 'c', Empty), 'z', Node (Empty, 'a', Empty)),
        'y', Node (Node (Empty, 'v', Empty), 'l', Node (Empty, 'i', Empty))),
      'b',
      Node (Node (Node (Empty, 'd', Empty), 'g', Node (Empty, 'v', Empty)),
       'g', Node (Node (Empty, 'x', Empty), 'h', Node (Empty, 'm', Empty)))))
Correct value true                                                              1 pt
Computing
  balanced
    (Node
      (Node (Node (Node (Empty, 'd', Node (Empty, 'b', Empty)), 'r', Empty),
        'v', Node (Empty, 's', Node (Empty, 'r', Empty))),
      'x',
      Node (Node (Node (Node (Empty, 'u', Empty), 't', Empty), 'e', Empty),
       'n', Node (Node (Empty, 'g', Node (Empty, 'y', Empty)), 'r', Empty))))
Correct value false                                                             1 pt
Computing
  balanced
    (Node
      (Node
        (Node (Node (Node (Empty, 'i', Empty), 't', Empty), 'q',
          Node (Empty, 'x', Node (Empty, 'r', Empty))),
        'e', Node (Empty, 'p', Node (Empty, 'c', Node (Empty, 'e', Empty)))),
      'm', Empty))
Correct value false                                                             1 pt
```