CS315 Homework 3

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1   The Mathematical Function

I chose my mathematical function to be `sum_until`. It has an integer parameter
and it returns the sum of all positive integers up to and including its parameter.
The implementation of this function is also recursive but that is not relevant
for this report. It is implemented as follows:

```
( define ( sum_until x)
    ( cond
        (( eq? x 0) 0)
        ( else (+ x ( sum_until(− x 1))))
    )
)
```

2   Product of the Mathematical Function

I chose to use product instead of sum here since the implementation of this
function would be exactly the same as the mathematical function if I chose to
implement sum. The product function is implemented as follows:

```
( define ( product−of−sum_until x)
    ( cond
        (( eq? x 0) 1)
        ( else (∗ ( sum_until x) ( product−of−sum_until (− x 1))))
    )
)
```

3 Tail Recursive Implementation

```
(define (product-of-sum_until-helper x product_partial)
        (cond
                ((eq? x 0) product_partial)
                (else (product-of-sum_until-helper (- x 1)
                        (* product_partial (sum_until x)))))
        )
)


(define (product-of-sum_until-tr x)
        (product-of-sum_until-helper x 1)
)
```

4 Trace Outputs

4.1 Non Tail Recursive

```
> (product-of-sum_until 0)
| > (product-of-sum_until 0)
| 1
1

> (product-of-sum_until 1)
| > (product-of-sum_until 1)
| | > (product-of-sum_until 0)
| | 1
| 1
1

> (product-of-sum_until 10)
| > (product-of-sum_until 10)
| | > (product-of-sum_until 9)
| | | > (product-of-sum_until 8)
| | | | > (product-of-sum_until 7)
| | | | | > (product-of-sum_until 6)
| | | | | | > (product-of-sum_until 5)
| | | | | | | > (product-of-sum_until 4)
| | | | | | | | > (product-of-sum_until 3)
| | | | | | | | | > (product-of-sum_until 2)
| | | | | | | | | | > (product-of-sum_until 1)
| | | | | | | | |[11] > (product-of-sum_until 0)
| | | | | | | | |[11] 1
| | | | | | | | | | | 1
| | | | | | | | | | 3
```

```
| | | | | | | | 18
| | | | | | | | 180
| | | | | | | 2700
| | | | | 56700
| | | | 1587600
| | | 57153600
| | 2571912000
| 141455160000
141455160000
```

4.2   Tail Recursive

```
> (product−of−sum_until−tr 0)
| > (product−of−sum_until−tr 0)
| > (product−of−sum_until−helper 0 1)
| 1
1


> (product−of−sum_until−tr 0)
| > (product−of−sum_until−tr 0)
| > (product−of−sum_until−helper 0 1)
| 1
1


> (product−of−sum_until−tr 10)
| > (product−of−sum_until−tr 10)
| > (product−of−sum_until−helper 10 1)
| > (product−of−sum_until−helper 9 55)
| > (product−of−sum_until−helper 8 2475)
| > (product−of−sum_until−helper 7 89100)
| > (product−of−sum_until−helper 6 2494800)
| > (product−of−sum_until−helper 5 52390800)
| > (product−of−sum_until−helper 4 785862000)
| > (product−of−sum_until−helper 3 7858620000)
| > (product−of−sum_until−helper 2 47151720000)
| > (product−of−sum_until−helper 1 141455160000)
| > (product−of−sum_until−helper 0 141455160000)
| 141455160000
141455160000
```