Preliminary information
This is your third Scam assignment. To run your code, use the following command:

```
scam FILENAME
```
or

```
scam -r FILENAME
```

where FILENAME is replaced by the name of the program you wish to run. The -r option will automatically run a no-argument function named main on startup.

All assignment submissions should supply a program named author.scm. This program should look like:

```
(define (main)
  (println "AUTHOR: Rita Recursion rrita@crimson.ua.edu")
)
```

with the name and email replaced by your own name and email.

For each numbered task (unless otherwise directed), you are to provide a program named taskN.scm, with the N corresponding to the task number, starting at one (as in task1.scm, task2.scm, and so on).

You may use assignment, unless otherwise directed. You may not use a looping function such as while or for, unless otherwise directed. Do not use the comment-out-the-rest-of-the-file comment in your code. On any line of output, there should be no leading whitespace and no trailing whitespace other than a newline (except when otherwise directed).

Tasks
1. Define a function named staticScope, which, when given an object, displays all the bindings in the static chain of that procedure object. The variable this is always bound to the current static scope. The cadr of this yields the set of variables bound in the current scope, while the caddr yields the corresponding list of variable values. The cadr of the values yields the enclosing static scope.

For example, consider executing the following code:

```
(define (f x)
  (define (g y)
    (define zz 3)
    (staticScope 3 this)
    (+ x y)
  )
  g)
)

(define z (f 3))

(z 4)
```

The call to staticScope should produce output similar to:

```
# [environment L0]
  y : 4
```
zz : 3
# [environment L1]
  g : # [user defined function (g y)]
  x : 3
# [environment L2]
  f : # [user defined function (f x)]

The second argument to the functions gives the number of scope levels to be printed. Giving a 0 as the number of levels should result in all levels being printed. L0 labels the innermost scope, while L1 labels the immediate enclosing scope, and so on. You should skip over the predefined variables and only list the explicitly defined local variables. Note there may be higher environments in your result. If a variable is uninitialized, the report binding should look similar to:
q : !!UNINITIALIZED!!

Example:

$ echo "(define (f x) (staticScope 1 this))" > task1.args
$ echo "(f 0)" >> task1.args
$ scam -r task1.scm task1.args

Both expressions read in by main should be evaluated.

2. Define a function named compile that replaces all the non-local variables in a function body with the values found in the definition environment. Should any of those values be function objects themselves, those objects would need to be compiled as well. The compile function should return its modified argument. The behavior of the compiled function must be unchanged, except it should run faster. You can retrieve the body and definition environment of a function with:

(define body (get 'code square))
(define denv (get '__context square))

respectively.

Here’s an example. Suppose we have the following definitions:

(define (square x) (multiply x x))
(define (multiply a b) (* a b))

Then:

(include "pretty.lib")
(compile square)
.pretty square
.pretty multiply

should output:

(define (square x)
  (<function multiply(a b)> x x)
)
(define (multiply a b)
  (<built-in *(@)> a b))

You will need to test whether or not the value of a symbol is a user-defined function or not (use the closure? function). Note, that if multiply references a user-defined function, then that function would also be compiled.

Use eval, catch, and error? to decide if a symbol in the function body is bound or free. If it is bound, leave the symbol in the body unchanged. Otherwise, replace the symbol with its value. You’ll need to test for the existence of a symbol in the definition environment of the function being compiled. You need not worry about nested functions. Note: closures are also objects in Scam.

You should use set-car! and set-cdr! to make replacements.

Include the pretty.lib library to gain access to the pretty function.

Note: a symbol in the body represents a variable if it is not wrapped in a call to quote.

Example:
3. Define a function, named `bst`, that constructs a binary search tree. The object that the constructor returns should implement the basic BST methods: `size`, `insert`, `find`, `delete`, `root`, `walk`, and `next`. The `size` method should return the number of nodes in the tree. The `root` method should return the root node of the tree. The `find` method should return the value associated with the given key and nil if the key is not in the tree. The behavior of the `walk` method is to return the “least” value in the BST, according to the comparator passed to the constructor. The `next` method should return the next value in an in-order traversal of the tree, with subsequent nodes being visited with each successive call to `next`. The `next` method should return nil when the search is exhausted. If an insertion or deletion occurs in the middle of the traversal, the behavior of `next` is unspecified. Note that having `find` and `next` return nil is a particularly bad design choice because it disallows nil values being stored in the tree (but it simplifies your task).

For testing purposes, all methods should handle an empty tree without failure. For those methods for which an empty tree is inappropriate, the return value is unspecified. Here are some sample series calls:

```scheme
(define tree (bst <)) ; smaller keys to the left
(tree 'insert 3 "mary") ; return value not specified
(tree 'insert 2 "jill")
(tree 'insert 6 "mark")
(tree 'size) ; should return 3
(tree 'find 6 =) ; should return "mark"
(tree 'find 5 =) ; should return nil
(tree 'walk) ; should return "jill"
(tree 'next) ; should return "mary"
(tree 'next) ; should return "mark"
(tree 'next) ; should return nil
(tree 'delete 2 =) ; should return "jill"
((bst <) 'delete 2 =) ; return value not specified
```

Your `main` function should insert each key-value pair supplied and then perform a complete walk of the newly made tree. It should then delete the root node of the tree and then do another complete walk. Each walk should be introduced with a print statement (shown in the example below). A complete walk of a tree should run in $O(n)$ time.

Example:

```
$ echo "((0 0) (1 1))" > task3.args
$ scam -r task3.scm task3.args
First walk:
0
1
Second walk:
1
```

Note: keys and values may be any type and a walk on an empty tree produces no output.
4. Using the imperative style of the text, implement a constraint network for the formula for determining the velocity right before impact when an object is dropped from a given height. The formula is:

\[ v = \sqrt{2gh} \]

where \( g \) is the gravitational acceleration and \( h \) is the drop height. While \( g \) is specified/reported in SI units, \( h \) is specified/reported in feet and \( v \) should be specified/reported in furlongs per fortnight. The constant \( g \) determined from the latitude using the formula:

\[ g = g_{45} - \frac{1}{7}(g_p - g_e) \times \cos(2 \times \text{lat} \times \frac{\pi}{180}) \]

where

- \( g_p = 9.832 \frac{m}{s^2} \)
- \( g_{45} = 9.806 \frac{m}{s^2} \)
- \( g_e = 9.780 \frac{m}{s^2} \)
- \( \text{lat} = \) latitude (between -90 and 90 degrees)

Name your network constructor \textit{speed}. Your network \textit{speed} should take three connectors as arguments, the velocity, the latitude, and the height, in that order.

Provide the following accessor and mutator functions \textit{get-value}, \textit{set-value!}, and \textit{forget-value!} as described on page 289 of the text.

Example:

$ echo "50000" > task4.args # furlongs per fortnight
$ echo "60" >> task4.args # latitude
$ scam -r task4.scm task4.args

the drop height should be around ??? feet
$

Round the result to 12 decimal places. Hint: use the \textit{fmt} function.

5. Define a synchronization barrier object using Scam’s binary semaphore. Name this function \textit{barrier}. You can use the \textit{gettid} function to access the ID of the thread asking for the semaphore.

Example calls:

\begin{verbatim}
(define b (barrier 3)) ; make a barrier for three threads
... ((b'start))
... ((b'finish))
\end{verbatim}

For this example, once three threads reach the starting point, the barrier is opened and the three threads (and only those three threads) can pass. When those three threads reach the finish line, three more threads can pass (and so on).

6. Define a variadic function named \textit{pfs} that, when given some prime numbers \( a, b, \ldots, z \), creates an infinite stream of integers whose only prime factors are \( a, b, \ldots, z \).

Example:

\begin{verbatim}
$ # (stream-display 3 (pfs 2))
$ echo 3 > task6.args
$ echo 2 >> task6.args
$ scam -r task6.scm task6.args

(2 4 8 ...)
$
\end{verbatim}

Constraints: \textit{stream-display} should not print any whitespace after the closing parenthesis.
7. Define a function named `twinPrimes` that produces a stream of twin prime pairs. Two primes are twinned if they differ in magnitude by \( n \) or less.

Example:

```sml
$ # (stream-display 2 (twinPrimes 3)) #display the first two twin prime pairs $ echo 2 > task7.args $ echo 3 >> task7.args $ scam -r task7.scm task7.args
((2 3) (3 5) ...)
```

Constraints: `stream-display` should not print any whitespace after the closing parenthesis.

8. Consider this summation:

\[
\sum_{n=1}^{\infty} (-1)^{n+1} \frac{x}{y^n}
\]

Define a function named `sum` that returns the stream that holds the terms of the above series for a given \( x \) and \( y \). Define a function named `psum` that produces the stream of partial sums of `(sum x)`. Define a function named `acc-psum` that accelerates `psum` stream using the Euler transform. Define a function named `super-acc-psum` that produces a super accelerated stream using a tableau of ever-accelerated partial sum streams. All of these function takes \( x \) and \( y \) as their arguments.

Example:

```sml
$ echo 1 >> task8.args # number of stream elements to display $ echo 3 >> task8.args # x $ echo 5 >> task8.args # y $ scam -r task8.scm task8.args
sum returns (0.6000000000 ...) psum returns (0.6000000000 ...) acc-psum returns (0.6000000000 ...) super-acc-psum returns (0.6000000000 ...) $```

Constraints: `stream-display` should not print any whitespace after the closing parenthesis.

9. Exercise 3.71 in the text. Define a function named `ramanujan` that produces a stream of Ramanujan numbers. The function takes no arguments.

Example:

```sml
$ # (stream-display 1 (ramanujan)) $ echo 1 > task9.args $ scam -r task9.scm task9.args
(1729 ...) $```

Constraints: `stream-display` should not print any whitespace after the closing parenthesis.

**Handing in the tasks**

For preliminary testing, send me all the files in your directory by running the command:

```
submit proglan luth test3
```

For your final submission, use the command:

```
submit proglan luth assign3
```