Welcome to Perl.

Aims

Getting started with Perl programming.

Assessment

Submission: `give cs2041 lab05 digits.pl echon.pl tail.pl`
also submit `shuffle.pl` and `shuffle_test.sh` if you attempt these challenge exercises
Deadline: either during the lab, or Monday 29 August 11:59pm (midnight)
Assessment: Make sure that you are familiar with the lab assessment criteria (lab/assessment.html).

Background

We have covered only a small amount of Perl in lectures. In fact, to cover the whole language in detail would take a whole semester, so we're going to rel
you finding out about the language yourself in tutes, labs and assignments. A good place to start is the Perl documentation & tutorial links on the class ho
page For example you might find these useful:

- Perl language syntax (http://search.cpan.org/dist/perl/pod/perlsyn.pod)
- Perl functions (http://search.cpan.org/dist/perl/pod/perlsub.pod)
- Perl operators (http://search.cpan.org/dist/perl/pod/perlop.pod)

Storing lab work on gitlab.cse.unsw.edu.au

For this and future labs you are going to use a version control system named git to store copies of your lab work in a repository at gitlab.cse.unsw.edu.au
Don't panic this is easy to do and will ensure you have a complete backup of all work on your lab and can return to its state at any stage.

It will also allow your tutor to check you are progressing on the lab as they can access your gitlab repository

Adding Your SSH Key to Gitlab

1. First print your CSE ssh key (if you have one:. This command should should do it.

```
$ cat ~/.ssh/id_rsa.pub
ssh-rsa AAAAB3NzaC1yc2EAAAABIwAAAQEAyNSzIDylSPAAGLzUXdw359UhO+tlN6wWprSBc9gu6t3IQ1
HhPoD6wcRXnonY6ytb00GpS4XRFuhCghx2JNVkXFykJYt3XNr1xkPItMmXr/DRIYrtxTs5sn9el3hHZIgE
8jJZpgIo303kgnF0MsB7XpqCzg7Iv6JGkv7aEoYC/MNr07hXE8iQjYIHDMdO9HxGI80GyMqb1hF+RSpQTN
QvH56juu9VXt5OwJjOqSVa4SfsEICqdn+3k9w8Z4EaD93Eeog3hz0RoTrme8h/sJenXydJ0w9ZOs0By4fj
FYPsYEs1K6SHma+kPByZM9COgKHZwOZHH1m24HOITQ== z5555555@williams
```

2. If you couldn't print a ssh key with the above command, you need to generate an ssh key. You can do it like this (just hit return for each questions).

```
$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/import/kamen/3/z5555555/.ssh/id_rsa):
Created directory '/import/kamen/3/z5555555/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /import/kamen/3/z5555555/.ssh/id_rsa.
Your public key has been saved in /import/kamen/3/z5555555/.ssh/id_rsa.pub.
The key fingerprint is:
b8:02:31:8b:bf:f5:56:fa:b0:1c:36:89:ad:e1:cb:ad z5555555@williams
The key's randomart image is:
...
```

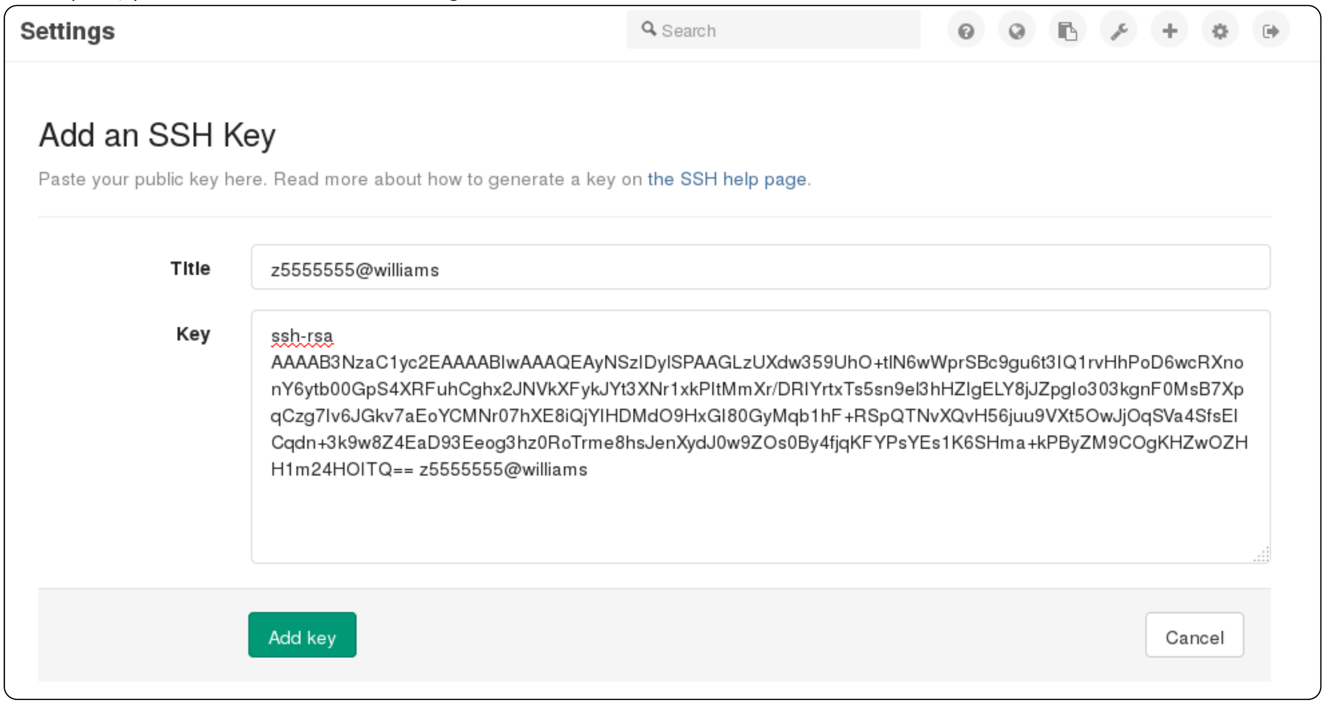
3. Now add your ssh key to gitlab:

4. Go to https://gitlab.cse.unsw.edu.au/profile/keys/new (https://gitlab.cse.unsw.edu.au/profile/keys/new) Click on Sign in

5. Supply your UNSW login (e.g. z5555555) and zPass and click the UNSW Sign in button.

6. Cut-and-paste your ssh-key (the entire 200+ character line printed by `cat ~/.ssh/id_rsa.pub`) into the "**Key**" field.
   Don't cut-and paste z5555555's ssh key above - cut-and-paste your ssh-key!

7. At this point, your screen should look something like this:



Add an SSH Key

Paste your public key here. Read more about how to generate a key on the SSH help page.

Title: z5555555@williams

Key:

```
ssh-rsa
AAAAB3NzaC1yc2EAAAABIwAAAQEAyNSzIDyISPAAGLzUXdw359UhO+tIN6wWprSBc9gu6t3IQ1rvHhPoD6wcRXno
nY6ytb00GpS4XRFuhCghx2JNVkXFykJYt3XNr1xkPItMmXr/DRIYrtxTs5sn9el3hHZIgELY8jJZpgIo303kgnF0MsB7Xp
qCzg7Iv6JGkv7aEoYCMNr07hXE8iQjYIHDMdO9HxGI80GyMqb1hF+RSpQTNvXQvH56juu9VXt5OwJjOqSVa4SfsEI
Cqdn+3k9w8Z4EaD93Eeog3hz0RoTrme8hsJenXydJ0w9ZOs0By4fjqKFYPsYEs1K6SHma+kPByZM9COgKHZwOZH
H1m24HOITQ== z5555555@williams
```

8. click the green Add key button

Creating a Git Repository in your CSE account

A repository for your COMP[29]041 labs has already been created for you on `gitlab.cse.unsw.edu.au`.

You'll also need a git repository for your labs in your CSE account.

The instructions below will create a new directory for your COMP[29]041 labs named **2041-labs**.

From now on put the files for each lab in a sub-directory of this lab.

You can if you wish move earlier labs into this directory as well but do this **after** following the instructions below.

Make sure you replace *5555555* below by your student number!

```
$ cd
$ git clone gitlab@gitlab.cse.unsw.EDU.AU:z5555555/16s2-comp2041-labs 2041-labs
Cloning into '2041-labs'...
$ chmod 700 2041-labs
$ cd 2041-labs
$ ln -sf /home/cs2041/public_html/scripts/autotest-pre-commit-hook .git/hooks/pre-commit
$ ls -la
drwx------   3 z5555555 z5555555  4096 Aug 27 14:44 .
drwxr-x--x 107 z5555555 z5555555 16384 Aug 27 14:51 ..
drwx------   7 z5555555 z5555555  4096 Aug 27 14:44 .git
drwx------   7 z5555555 z5555555  4096 Aug 27 14:44 lab05
drwx------   7 z5555555 z5555555  4096 Aug 27 14:44 lab06
...
$ cd lab05
```

You now have a git repository in your CSE account for this and future week's lab work. The sub-directory `.git` is where git stores information.

Create the files for this week's lab in **2041-labs/lab05** and push them to gitlab.cse.unsw.edu.au when every you make some progress.

BTW the line

```
$ ln -s /home/cs2041/public_html/16s2/scripts/autotest-pre-commit-hook .git/hooks/pre-commit
```

results in git running autotests for every commit. This should be useful to you and is small example of customizing git for building a software system.

Exercise: Mapping Digits

Write a Perl script `digits.pl` that reads from standard input and writes to standard output mapping all digit characters whose values are less than 5 into character ' < ' and all digit characters whose values are greater than 5 into the character ' > '. The digit character '5' should be left unchanged.

Sample Input Data	**Corresponding Output**
`1 234 5 678 9`	`< <<< 5 >>> >`
`I can think of 100's`	`I can think of <<<'s`
`of other things I'd rather`	`of other things I'd rather`
`be doing than these 3 questions`	`be doing than these < questions`
`A line with lots of numbers:`	`A line with lots of numbers:`
`123456789123456789123456789`	`<<<<5>>>><<<<5>>>><<<<5>>>>`
`A line with all zeroes`	`A line with all zeroes`
`00000000000000000000000000`	`<<<<<<<<<<<<<<<<<<<<<<<<<<`
`A line with blanks at the end`	`A line with blanks at the end`
`1 2 3`	`< < <`
`Input with absolutely 0 digits in it`	`Input with absolutely < digits in it`
`Well ... apart from that one ...`	`Well ... apart from that one ...`
`1 2 4 8 16 32 64 128 256 512 1024`	`< < < > <> << >< <<> <5> 5<< <<<<`
`2048 4096 8192 16384 32768 65536`	`<<<> <<>> ><>< <><>< <<>>> >55<>`

Sample solution #0 for digits.pl

```perl
#!/usr/bin/perl -w
while ($line = <STDIN>) {
    $line =~ s/[0-4]/</g;
    $line =~ s/[6-9]/>/g;
    print $line;
}
```

Sample solution #1 for digits.pl

```perl
#!/usr/bin/perl -w
# using the implicit variable $_
while (<STDIN>) {
    s/[0-4]/</g;
    s/[6-9]/>/g;
    print;
}
```

Sample solution #2 for digits.pl

```perl
#!/usr/bin/perl -w
while (<STDIN>) {
    tr/0-9/<<<<<5>>>>/;
    print;
}
```

As usual you can run some tests on your script like this:

```
$ ~cs2041/bin/autotest lab05 digits.pl
```

Also do your own testing!

Pushing to gitlab.cse.unsw.edu.au

When you make some progress with `digits.pl` do this to push it to gitlab.cse.unsw.edu.au.

```
$ git add digits.pl
$ git commit -a -m "first version"
[master 4cdfa5f] first version
 1 file changed, 17 insertions(+)
 create mode 100755 .pl
$ git push -u origin master
Counting objects: 3, done.
Delta compression using up to 4 threads.
Compressing objects: 100% (2/2), done.
Writing objects: 100% (2/2), 239 bytes, done.
Total 2 (delta 1), reused 0 (delta 0)
To gitlab@calliope1.cse.unsw.EDU.AU:z5555555/16s2-comp2041-labs.git
   36ccb2b..4cdfa5f  master -> master
```

Later on when you have made more progress with `digits.pl` do this to commit the new version & push it to gitlab.

```
$ git commit -a -m "digits.pl passes autotests"
...
$ git push
```

If you explore at https://gitlab.cse.unsw.edu.au/z*5555555*/16s2-comp2041-labs (replacing *5555555* with your student number you'll find both versions o `digits.pl`

Follow the same steps for all the programs you write from now on for COMP[29]041.

Exercise: Repeated Echo

Write a Perl script `echon.pl` which given exactly two arguments, an integer *n* and a string, prints the string *n* times. For example:

```
$ ./echon.pl 5 hello
hello
hello
hello
hello
hello
```

```
$ ./echon.pl 0 nothing
```

```
$ ./echon.pl 1 goodbye
goodbye
```

Your script should print an error message if it is not given exactly 2 arguments. For example:

```
$ ./echon.pl
Usage: ./echon.pl <number of lines> <string>
```

```
$ ./echon.pl 1 2 3
Usage: ./echon.pl <number of lines> <string>
```

Sample solution #0 for echon.pl

```
#!/usr/bin/perl -w
if (@ARGV != 2) {
    die "Usage: $0 <number of lines> <string>\n";
}
if ($ARGV[0] !~ /^\d+$/) {
    die "$0: argument 1 must be a non-negative integer\n";
}
foreach ($i=0; $i < $ARGV[0]; $i++) {
    print "$ARGV[1]\n";
}
```

Sample solution #1 for echon.pl

```
#!/usr/bin/perl -w
die "Usage: $0 <number of lines> <string>\n" if @ARGV != 2;
die "$0: argument 1 must be a non-negative integer\n" if $ARGV[0] !~ /^\d+$/;
foreach (1..$ARGV[0]) {
    print "$ARGV[1]\n";
}
```

Sample solution #2 for echon.pl

```
#!/usr/bin/perl -w
die "Usage: $0 <number of lines> <string>\n" if @ARGV != 2;
die "$0: argument 1 must be a non-negative integer\n" if $ARGV[0] !~ /^\d+$/;
print "$ARGV[1]\n" foreach 1..$ARGV[0];
```

Sample solution #3 for echon.pl

```
#!/usr/bin/perl -w
die "Usage: $0 <number of lines> <string>\n" if @ARGV != 2;
die "$0: argument 1 must be a non-negative integer\n" if $ARGV[0] !~ /^\d+$/;
print "$ARGV[1]\n" x $ARGV[0];
```

As usual use `autotest` to assist in testing your code and push `echon.pl` to `gitlab.cse.unsw.edu.au` every time you make some progress with it.

```
$ ~cs2041/bin/autotest lab05 echon.pl
...
$ git add echon.pl
$ git commit -a -m "first version of echon.pl"
...
$ git push
...
```

Exercise: Tail

Perl file manipulation

The standard approach in Perl for dealing with a collection of files whose names are supplied as command line arguments, is something like:

```
#!/usr/bin/perl -w
@files = ();
foreach $arg (@ARGV) {
    if ($arg eq "--version") {
        print "$0: version 0.1\n";
        exit(0);
    }
    # handle other options
    # ...
    else {
        push @files, $arg;
    }
}
foreach $f (@files) {
    open(F,"<$f") or die "$0: Can't open $f: $!\n";
    # process F
    #...
    close(F);
}
```

Write a Perl script to implement the Unix `tail` command. It should support the following features of `tail`:

- read from files supplied as command line arguments
- read from standard input if no file name arguments are supplied
- display the error message `tail.pl: can't open` *FileName* for any unreadable file
- display the last *N* lines of each file (default *N* = 10)
- can adjust the number of lines displayed via an optional first argument –*N*
- if there are more than one named files, separate each by `==>` *FileName* `<==`

To assist with testing your solution, there are three small t files: t1.txt (lab/perl/tail/t1.txt), t2.txt (lab/perl/tail/t2.txt), and t3.txt (lab/perl/tail/t3.txt). Co
these files to your current directory.

```
$ cp /home/cs2041/public_html/lab/perl/tail/t?.txt .
```

Using these data files, your program should behave as follows:

```
$ ./tail.pl <t1.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
$ ./tail.pl t1.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
$ ./tail.pl -5 t1.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
$ ./tail.pl -5 t2.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
```

```
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
$ ./tail.pl -5 t1.txt t2.txt t3.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
$ ./tail.pl -2 tX.txt
String found where operator expected at ./tail.pl line 16, near "$file" or die ""
        (Missing operator before " or die "?)
Scalar found where operator expected at ./tail.pl line 16, near "" or die "$0"
        (Missing operator before $0?)
Backslash found where operator expected at ./tail.pl line 16, near "$file\"
        (Missing operator before \?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 16.
String found where operator expected at ./tail.pl line 17, near "print ""
  (Might be a runaway multi-line "" string starting on line 16)
        (Missing semicolon on previous line?)
Unquoted string "n" may clash with future reserved word at ./tail.pl line 17.
String found where operator expected at ./tail.pl line 17, at end of line
        (Missing semicolon on previous line?)
syntax error at ./tail.pl line 16, near "$file" or die ""
Can't find string terminator '"' anywhere before EOF at ./tail.pl line 17.
```

Hint: use the above template for Perl file processing to get started with your script. You *must* use the `-w` flag in your script, and you must write your cod such a way as to ensure that no warning messages are produced.

Sample solution for tail.pl

```
#!/usr/bin/perl -w

$max = 10;
if (@ARGV > 0 && $ARGV[0] =~ /-([0-9]+)/) {
    ($max = $ARGV[0]) =~ s/-//;;
    shift @ARGV;
}
if (@ARGV == 0) {
    @lines = <>;
    $first = @lines - $max;
    $first = 0 if $first < 0;
    print @lines[$first..$#lines];
} else {
    $showFnames = (@ARGV > 1);
    foreach $file (@ARGV) {
        open my $f, '<', $file" or die "$0: can't open $file\n";
        print "==> $file <==\n" if ($showFnames);
        @lines = <$f>;
        $first = @lines - $max;
        $first = 0 if $first < 0;
        print @lines[$first..$#lines];
        close $f;
    }
}
```

As usual use `autotest` to assist in testing your code and push `echon.pl` to `gitlab.cse.unsw.edu.au` every time you make some progress with it.

```
$ ~cs2041/bin/autotest lab05 tail.pl
...
$ git add tail.pl
$ git commit -a -m "initial tail.pl"
...
$ git push
...
```

Challenge Exercise: Shuffling Lines

Write a Perl script `shuffle.pl` which prints its input with the lines in random order. For example:

```
$ i=0;while test $i -lt 5; do echo $i; i=$((i + 1)); done|./shuffle.pl
3
4
1
0
2
```

```
$ i=0;while test $i -lt 5; do echo $i; i=$((i + 1)); done|./shuffle.pl
1
2
4
3
0
```

You are not permitted to use `List::Util` (it contains a shuffle function).
Don't look for other people solutions - see if you can come up with your own. **Hint:** the perl function *rand* returns a floating point number between 0 and argument. For example:

```
$ perl -e 'print rand(42), "\n"'
16.4481193249323
$ perl -e 'print rand(42), "\n"'
34.5678552867122
```

Hint: perl ignores the fractional part of a number if you use it to index an array

Sample solution for shuffle.pl

```
#!/usr/bin/perl -w
# simple implementation of http://en.wikipedia.org/wiki/Fisher-Yates_shuffle
@lines = <>;
print splice(@lines, rand(@lines), 1) while @lines;
```

Sample solution using List::Util

```
#!/usr/bin/perl -w
use List::Util 'shuffle';
print shuffle(<>);
```

Challenge Question: Testing Shuffling Lines

There is no dryrun test for `shuffle.pl`. Testing (pseudo)random programs is more difficult. because there are multiple correct outputs for a given input.

Write a shell script `shuffle_test.sh` which tests `shuffle.pl`.

Try to test that all outputs are correct and all correct outputs are being generated.

Sample solution that just checks coverage

```
#!/bin/sh

input=/tmp/shuffle_test0$$
output=/tmp/shuffle_test1$$
sorted_output=/tmp/shuffle_test2$$
all_output=/tmp/shuffle_test3$$

number_of_lines=4
number_of_test_runs=256

# create an input file with 1 integer per line in sorted order
# and calculate how many permutations are possible
i=1
factorial=1
while test $i -le $number_of_lines
do
    echo $i
    factorial=$(($factorial * $i))
    i=$(($i + 1))
done >$input

run=1
while test $run -le $number_of_test_runs
do
    ./shuffle.pl <$input >$output
    sort -n $output >$sorted_output

    # after sorting output should be identical to input
    if diff $sorted_output $input >/dev/null
    then
        # append result of this execution to $all_output as a single line
        echo `cat $output` >>$all_output
    else
        echo Testing failed, input was:
        cat $input
        echo Testing failed, output was:
        cat $output
        exit 1
    fi
    run=$(($run + 1))
done

n_different_outputs=`sort $all_output|uniq|wc -l`
if test $n_different_outputs -eq $factorial
then
    echo All possible outputs produced
    exit 0
else
    echo In $number_of_test_runs executions only $n_different_outputs of $factorial outputs produced
    exit 1
fi

rm -f $input $output $sorted_output $all_output
```

A more elaborate solution from Donny Yang which takes a more statistical approach

```
#!/bin/sh

input=/tmp/shuffle_test0$$
output=/tmp/shuffle_test1$$
sorted_output=/tmp/shuffle_test2$$
all_output=/tmp/shuffle_test3$$

number_of_lines=4
number_of_test_runs=256

# create an input file with 1 integer per line in sorted order
# and calculate how many permutations are possible
i=1
factorial=1
while test $i -le $number_of_lines
do
    echo $i
    factorial=$(($factorial * $i))
    i=$(($i + 1))
done >$input

run=1
while test $run -le $number_of_test_runs
do
    ./shuffle.pl <$input >$output
    sort -n $output >$sorted_output

    # after sorting output should be identical to input
    if diff $sorted_output $input >/dev/null
    then
        # append result of this execution to $all_output as a single line
        echo `cat $output` >>$all_output
    else
        echo Testing failed, input was:
        cat $input
        echo Testing failed, output was:
        cat $output
        exit 1
    fi
    run=$(($run + 1))
done

n_different_outputs=`sort $all_output|uniq|wc -l`
if test $n_different_outputs -eq $factorial
then
    echo All possible outputs produced
    exit 0
else
    echo In $number_of_test_runs executions only $n_different_outputs of $factorial outputs produced
    exit 1
fi

rm -f $input $output $sorted_output $all_output
```

Don't forget to push `shuffle.pl` and `shuffle_test.sh` to `gitlab.cse.unsw.edu.au` if and when you work on them.

Finalising

You must show your solutions to your tutor and be able to explain how they work. Once your tutor has discussed your answers with you, you should subm
them using:

```
$ give cs2041 lab05 digits.pl echon.pl tail.pl [shuffle.pl shuffle_test.sh]
```

Whether you discuss your solutions with your tutor this week or next week, you must submit them before the above deadline.