Problem:

Ask the user for two integer **n** and **m where m>n**.

Create a list x of size n. Populate the list with n **random integers** in the range 1through m.

Problem:

Modify the answer to the problem above so that all of the integers in list x are **unique**.

Sets

Like a list, a set is a “container” that gives us a place to store a collection of elements.
Unlike a list, a set can contain **only one copy** of any element.

```
>>>
>>> s=set()
>>> s.add(1)
>>> s.add(2)
>>> s
{1, 2}
>>> s.add(1)
>>> s
{1, 2}
>>>
```

We can use Python’s built-in **set** container to check for duplicates.

We can create a set S with the following syntax:

s=set([iterable])

S=set() creates an initially empty set.

If IT is some iterable (like a set) the s=set(IT) creates a set that is initialized with the elements of IT (for example a list)

The set provides the following operations (among others):

add(elem)
Add element elem to the set.
remove(elem)
Remove element elem from the set. Raises KeyError if elem is not contained in the set.
discard(elem)
Remove element elem from the set if it is present.
pop()
Remove and return an arbitrary element from the set. Raises KeyError if the set is empty.
clear()
Remove all elements from the set.
len(s)
Return the cardinality (number of elements) of set s.
x in s
Test x for membership in s.
x not in s
Test x for non-membership in s.

Problem:

Ask the user for three integer **n** and **m and k, where k>m*n**.

Create a two dimensional table (list of lists) x of size n*m. Populate the list with n*m **unique random integers** in the range 1through k.

Problem:

Write a function get_row(x,i) which **takes a square matrix** (=table=list of lists) and **returns a list** containing the ith row of matrix X.

Problem:

Write a function get_col(x,i) which **takes a square matrix** (=table=list of lists) and **returns a list** containing the ith column of matrix X.

Problem:

Write a function to calculate and return the sum of all the elements on the "main diagonal" of the square two dimensional list x passed to it as an argument. This is the diagonal going from the <u>upper left to the bottom right.</u>

Problem:

Like the problem above, calculate and return the diagonal sum, but for the elements along the diagonal going from the top right to the lower left.

List Comprehensions

A list comprehension is a very compact and useful notation that Python provides for **creating lists**.

It is very similar to the notation that is uses in math for specifying sets. For example it is pretty clear what this means:

$$\{x^2 : 1 \le x \le 100 \text{ , if x is even}\}$$

It is the set of the squares of the even numbers between 1 and 100.

Here is a list comprehension that creates a list with the same numbers:

```
>>>
>>> a=[x**2 for x in range(1,101) if x%2==0]
>>> a
[4, 16, 36, 64, 100, 144, 196, 256, 324, 400, 484, 576, 676, 784, 900, 1024, 1156,
1296, 1444, 1600, 1764, 1936, 2116, 2304, 2500, 2704, 2916, 3136, 3364, 3600, 3844
, 4096, 4356, 4624, 4900, 5184, 5476, 5776, 6084, 6400, 6724, 7056, 7396, 7744, 81
00, 8464, 8836, 9216, 9604, 10000]
>>>
>>>
```

Notice that this is equivalent to the following:

```
a=[]
for x in range(1,101):
    if x%2==0:
        a.append(x)
```

The list comprehension notation is more compact and much clearer (once you get used to it) than the equivalent code above

The general form has three components:

[expression using a value from an iterable   for iterable   if conditions]

(1)   (2)   (3)

Some more examples:

Example:

Assume that we have a function prime(i) which returns True if i is s prime number and False otherwise.

Create a list of all the primes between 2 and 120.

y = [k   for k in range(2, 121)   if prime(k)   ]

Example:

Let x and y be two lists of numbers, both of length n. To get the **dot product** of x and y we do the following:

- form the pairs x[i]*y[i] for 0 ≤ i < n
- sum up all the pairs.

For example:

x=[1,2,3] and y=[10,11,12] then x·y=1*10+2*11+3*12.

We can write this as list comprehension like this:

```
>>>
>>> x=[1,2,3]
>>> y=[10,11,12]
>>> z=sum([x[i]*y[i] for i in range(len(x))])
>>> z
68
>>>
>>>
```

Example:

Let z be a list of 20 integers, and we want a **list of tuples** giving the value and position of each even number in the list. The following will do this:

```
>>> z
[13, 14, 7, 12, 11, 3, 18, 20, 5, 7, 19, 17, 10, 16, 14, 12, 5, 19, 15, 1]
>>> k=[ ( i , z[i] )  for i in range(20)    if z[i]%2==0 ]
>>> k
[(1, 14), (3, 12), (6, 18), (7, 20), (12, 10), (13, 16), (14, 14), (15, 12)]
>>>
```

Example:

Write a function get_row(x,i) which **takes a square matrix** (=table=list of lists) and **returns a list** containing the element in the ith **row** of matrix X.

Using a list comprehension we could write:

```
def get_row(x,i):
    return [ x[i][j] for j in range(len(x)) ]
```

Or …we could also write

```
def get_row(x,i):
    return x[i]
```

since the ith row of x is just the ith sublist of x.

However there is an **important difference between these two implementations** of get_row().

The first version creates a new list made up of the elements of row i of matrix X.

The second one, which is much faster, just returns a reference to the ith row of matrix X.

In the following example, we call **both** versions of get_row(m,0) on the matrix **m=[[1,2],[3,4]].**

Notice that both versions return what **seems to be** the same result: [1, 2]

```
>>>
>>> def get_row(x,i):
        return [ x[i][j] for j in range(len(x)) ]

>>> m=[[1,2],[3,4]]
>>> m
[[1, 2], [3, 4]]
>>> b=get_row(m,0)
>>> b
[1, 2]
>>>
>>> def get_row(x,i):
        return x[i]

>>> b=get_row(m,0)
>>> b
[1, 2]
>>>
>>>
```

Question: What is the important **practical difference** between the two versions?

Hint: What happens when we change list b after it is returned from get_row(). Why does this happen?

Example:

Write a function get_col(x,i) which **takes a square matrix** (=table=list of lists) and **returns a list** containing the items in the ith **column** of matrix X.

```
def get_col(x,i):
    return [ x[j][i] for j in range(len(x)) ]
```

Problem:

Write a function sum_col(x,i) which **takes a square matrix** (=table=list of lists) and **the sum of** the items in the ith **column** of matrix X. Use a list comprehension.

Problem:

Write a function diag_diff(x,i) which **takes a square matrix** (=table=list of lists) and **the difference of two main diagonals of matrix X.** In other words, let d1 be the diagonal of X from upper left to bottom right, and d2 to be the diagonal from upper right to lower left. The function returns d1-d2. Use list comprehensions**.**

Problem:

Early versions of Python distinguished between int and long. ints were represented natively on the hardware and longs were lists of integers. From version 3.0 and on all integer types are represented as longs.

Write a function **make_int (x: str) -> list:**

that takes a string of digits and returns a list of those digits. Use a list comprehension.

Problem:

Write a function int_add(x,y) that takes two "integers" as represented above, and returns their sum.

<u>Note</u> that these "integers" needn't be the same size. You can simplify your program by padding the shorter one with zeros (on the left).

<u>Note as well</u>, there might be a final carry that will increase the answer by one digit more than the addends.

Problem:

Write a function matrix_add(x,y) that takes two square "matrices" and returns their sum.

Problem:

Write a function matrix_mult(x,y) that takes two square "matrices" and returns their product.

Problem:

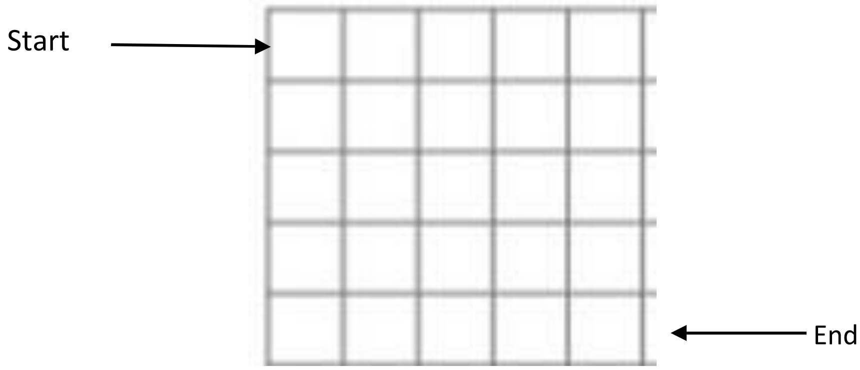
<u>Now, here is a definition</u>: A **saddle point** in a 2 dimensional square table is an entry in the table whose value is the minimum in its row **and** maximum in its column. In the table below, 0 is a saddle point.

2	0
0	-2

Write a function to find a saddle point in a 2 dimensional table in any two dimensional square of integers, if one exists. If a saddle point was found return a triple (value, x pos, y pos). If a saddle point was not found return "not found"

Problem:

. Consider the 5X5 square below:



We would like to have a robot travel from the start square at the upper left to the end square at the lower right. At each square the robot has only one of two moves:

- It may go one square to the right or
- It may go one square down.

Write a program that determines in how many ways may this be done? In other words, how many paths are there from start to end with each move restricted as above?

Solution:

```
#robot paths
a=[5*[0] for i in range (5)]
#set up the left and top boundaries of the table (5X5 square array)
for i in range(5):
    a[i][0]=1
    a[0][i]=1

for i in range(1,5):
    for j in range(1,5):
        a[i][j]=a[i-1][j]+a[i][j-1]

print(a[4][4])
```

Here is another approach. Can you figure out how this works? What happened to the table??

```
n=int(input("Please enter the 'size' of the array, n= "))

def num_paths(n,i,j):
    if i==0 or j ==0:
        return 1
    return num_paths(n,i-1,j)+num_paths(n,i,j-1)

print(num_paths(n, n-1, n-1))
```

Problem:

Write a program to generate all the eight-digit base 8 integers from 00000000➔77777777

What is a base eight integer?

The following code will do it.

```
for i0 in range(8):
    for i1 in range(8):
        for i2 in range(8):
            for i3 in range(8):
                for i4 in range(8):
                    for i5 in range(8):
                        for i6 in range(8):
                            for i7 in range(8):
                                q=[i0,i1,i2,i3,i4,i5,i6,i7]
                                print(q)
```

Problem:

Write a function get_num(n) which returns a list of length 8 representing the base eight representation of the decimal number n.

Problem:

Remember the Eight Queens Problem? Using the code above, we can generate all 8^8 configurations and print only those that have neither a row nor a diagonal conflict.

<u>The algorithm</u>

<u>The row test (its trivial in Python)</u>

<u>The diagonal test</u>

Here is another way:

```
def diagonal_threat(q):



from itertools import permutations
candidates=permutations([0,1,2,3,4,5,6,7])

count=0
for p in candidates:
    if diagonal_threat(p):
      continue
    count+=1
    print('Solution number ', count,': ',p)
    print()
```

Before we move on to strings, let's revisit

Unpacking Sequences and Iterables

We covered some of this before, but we review here and look at some additional uses.

Unpacking is important because it avoids unnecessary and error-prone use of indexes to extract elements from sequences. Also, unpacking works with any iterable object as the data source—including iterators, which don't support index notation ([]). The only requirement is that the iterable yields exactly one item per variable in the receiving end, unless you use a star (*) to capture excess items, as explained below

Parallel Assignment

The most visible form of unpacking is parallel assignment; that is, assigning items from an iterable to a tuple of variables, as you can see in this example:

```
>>> lax_coordinates = (33.9425, -118.408056)
>>> latitude, longitude = lax_coordinates  # unpacking
>>> latitude
33.9425
>>> longitude
-118.408056
```

An elegant application of unpacking is swapping the values of variables without using a temporary variable:

```
>>> b, a = a, b
```

Another example of unpacking is **prefixing an argument with * when calling a function:**

```
>>> divmod(20, 8) # returns the divisor and remainder
(2, 4)
>>> t = (20, 8)
>>> divmod(*t)
(2, 4)
>>> quotient, remainder = divmod(*t) # in this case the t variable is the "args"
>>> quotient, remainder
(2, 4)
```

In other wors:

```
>>> divmod(10,2)
(5, 0)
>>> q=(10,2)
>>> divmod(q)
Traceback (most recent call last):
  File "<pyshell#2>", line 1, in <module>
    divmod(q)
TypeError: divmod expected 2 arguments, got 1
>>> divmod(*q)
(5, 0)
```

The preceding code shows another use of unpacking: allowing functions to return multiple values in a way that is convenient to the caller. As another example**, the os.path.split() function builds a tuple (path, last_part) from a filesystem path:**

```
>>> import os
>>> _, filename = os.path.split('/home/luciano/.ssh/id_rsa.pub')
>>> filename # matches the last part
'id_rsa.pub'
```

Another way of using just some of the items when unpacking is to use the * syntax, as we'll see right away.

Using * to Grab Excess Items

Defining function parameters with *args to grab arbitrary excess arguments is a classic Python feature.

We worked on the following example where we passed in an arbitrary number of arguments:

Problem: Write a function "addem" that returns the sum of an arbitrary number of numbers.

so addem(1,2) ==>3 and addem(1,2,3)==> 6.

In Python 3, this idea was **extended to apply to parallel assignment** as well:

```
>>> a, b, *rest = range(5)
>>> a, b, rest
(0, 1, [2, 3, 4])
>>> a, b, *rest = range(3)
>>> a, b, rest
(0, 1, [2])
>>> a, b, *rest = range(2)
>>> a, b, rest
(0, 1, [])
```

Note that the excess items get put into a list.

In the context of parallel assignment, the * prefix can be applied to exactly one variable, but it can appear in any position:

```
>>> a, *body, c, d = range(5)
>>> a, body, c, d
(0, [1, 2], 3, 4)
>>> *head, b, c, d = range(5)
>>> head, b, c, d
([0, 1], 2, 3, 4)
```

Unpacking with * in **Function Calls and Sequence Literals**

In function <u>calls</u>, we can use * multiple times:

```
>>> def fun(a, b, c, d, *rest):
...     return a, b, c, d, rest
...
>>> fun(*[1, 2], 3, *range(4, 7))
(1, 2, 3, 4, (5, 6))
```

Notice the 5 and 6 are put into a <u>tuple</u> because of the * in the function header**.**

The * can also be used when defining list, tuple, or set literals, as shown in the following examples.

```
>>> *range(4), 4
(0, 1, 2, 3, 4) # all got unpacked into a tuple by default

>>> [*range(4), 4]
[0, 1, 2, 3, 4] # unpacked into a list because …
>>> {*range(4), 4, *(5, 6, 7)}
{0, 1, 2, 3, 4, 5, 6, 7} # and to a set because …
```

Finally, a powerful feature of tuple unpacking is that it works with nested structures.

Nested Unpacking

The target (what you are unpacking into) of an unpacking can use nesting, e.g., (a, b, (c, d)). Python will do the right thing if the value has the same nesting structure.

Example: Unpacking nested tuples to access the longitude

```
metro_areas = [
    ('Tokyo', 'JP', 36.933, (35.689722, 139.691667)),
    ('Delhi NCR', 'IN', 21.935, (28.613889, 77.208889)),
    ('Mexico City', 'MX', 20.142, (19.433333, -99.133333)),
    ('New York-Newark', 'US', 20.104, (40.808611, -74.020386)),
    ('São Paulo', 'BR', 19.649, (-23.547778, -46.635833)),
]

def main():
    print(f'{"":15} | {"latitude":>9} | {"longitude":>9}')
    for name, _, _, (lat, lon) in metro_areas:
        if lon <= 0:
            print(f'{name:15} | {lat:9.4f} | {lon:9.4f}')
```

Each tuple holds a record with four fields, the last of which is a coordinate pair.

By assigning the last field to a nested tuple, we unpack the coordinates.

The lon <= 0: test selects only cities in the Western hemisphere.

The output is:

```
                |  latitude | longitude
Mexico City     |   19.4333 |  -99.1333
New York-Newark |   40.8086 |  -74.0204
São Paulo       |  -23.5478 |  -46.6358
```

More on Strings … and Files

We have been using strings all along. Some of the things we have seen include:

- Strings are immutable.
- Strings are iterables so we can use "for".
- Since strings are sequences, we can access elements and substrings them [].
- We can concatenate strings: s1+s2.

But Python provides many many functions for working with strings. Let's check out some of the functions as described in the online documentation. The full list is in the Python Library Reference documentation in section 4.6.1.

Here are some of the most useful with definitions and examples from the Library Reference. .

`str.count`(*sub*[, *start*[, *end*]])

> Return the number of non-overlapping occurrences of substring *sub* in the range [*start*, *end*]. Optional arguments *start* and *end* are interpreted as in slice notation.

`str.find`(*sub*[, *start*[, *end*]])

> Return the lowest index in the string where substring *sub* is found, such that *sub* is contained in the slice `s[start:end]`. Optional arguments *start* and *end* are interpreted as in slice notation. Return `-1` if *sub* is not found.

`str.join`(*iterable*)

> **Return a string which is the concatenation of the strings in the *iterable*** *iterable*. A `TypeError` will be raised if there are any non-string values in *seq*, including `bytes` objects. The separator between elements is the string providing this method.

`str.replace`(*old*, *new*[, *count*])

> Return a copy of the string with all occurrences of substring *old* replaced by *new*. If the optional argument *count* is given, only the first *count* occurrences are replaced.

`str.split`([*sep*[, *maxsplit*]])

> **Return a list of the words in the string**, using *sep* as the delimiter string. If *maxsplit* is given, at most *maxsplit* splits are done (thus, the list will have at most `maxsplit+1` elements). If *maxsplit* is not specified, then there is no limit on the number of splits (all possible splits are made).
>
> If *sep* is given, consecutive delimiters are not grouped together and are deemed to delimit empty strings (for example, `'1,,2'.split(',')` returns `['1', '', '2']`). The *sep* argument may consist of multiple characters (for example, `'1<>2<>3'.split('<>')` returns `['1', '2', '3']`). Splitting an empty string with a specified separator returns `['']`.

If *sep* is not specified or is `None`, a different splitting algorithm is applied: runs of consecutive whitespace are regarded as a single separator, and the result will contain no empty strings at the start or end if the string has leading or trailing whitespace. Consequently, splitting an empty string or a string consisting of just whitespace with a `None` separator returns `[]`.

For example, `' 1  2   3  '.split()` returns `['1', '2', '3']`, and `'  1  2   3  '.split(None, 1)` returns `['1', '2   3`

`str.splitlines`([*keepends*])

Return a list of the lines in the string, breaking at line boundaries. **Line breaks are not included in the resulting list** unless *keepends* is given and true.

`str.rstrip`([*chars*])

Return a copy of the string with trailing characters removed. The *chars* argument is a string specifying the set of characters to be removed. If omitted or `None`, the *chars* argument defaults to removing whitespace. **The *chars* argument is not a suffix; rather, all combinations of its values are stripped:**

There are also functions lstrip() and rstrip() that act in the expected way.

`str.upper`()

Return a copy of the string converted to uppercase.

`str.lower`()

Return a copy of the string converted to lowercase

Problem:

Write a function that reverses a string. Remember, a string is not mutable! Do it two ways.

Answer:

Problem:

Write a function is_len(s,n) which returns True if string s is at least n characters long, and False otherwise.

Answer:

Problem:

Write a function one_upper(s) which returns True if **exactly one** character in string s is capitalized, and False otherwise. You can assume that the string s contains only alphabetic characters and no blanks. You might want to consider other string functions from the documentation.

Answer:

Problem:

Write a function clear(x) where x is a list of “words”. Each word is a string that might have either a ‘.’ ‘,’, or’;’ tacked on at the end. clear() will return a list with the original words stripped of the punctuation.

```
>>>
>>> a=['asd','er.','rt,','fgh;']
>>> clear(a)
['asd', 'er', 'rt', 'fgh']
>>>
```

Answer:

Problem:

What about removing the unwanted characters from the right end? What about from both ends? What about from anywhere in the string?

Answer:

Problem:

Write a **function scrape(s)** which take a string s representing the HTML of a web page and returns a list of all links found on the page. We recognize the beginning of a link by looking for ‘http://’.

Answer:

Problem: Count the ones.

Write a program that prompts the user for some integer n, and calculates the number of occurrences of the digit ‘1’ in all the numbers from 1-n inclusive.

For example, if n=20 the program will print 12 since

1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20.

Files: Input and Output

Basic file operations

output = open('C:\spam', 'w')	Create output file ('w'means write)
input = open('data', 'r')	Create input file ('r'means read)
input = open('data')	Same as prior line ('r'is the default)
aString = input.read()	Read entire file into a single string
aString = input.read(N)	Read up to next Ncharacters (or bytes) into a string
aString = input.readline()	Read next line (including \nnewline) into a string
aList = input.readlines()	Read entire file into list of line strings (with \n)
output.write(aString)	Write a string of characters (or bytes) into file
output.writelines(aList)	Write all line strings in a list into file
print(value, …file='filename')	**Write to file "filename" instead of to the screen**
output.close()	Manual close (done for you when file is collected)
output.flush()	Flush output buffer to disk without closing any File.
seek(N)	Change file position to offset Nfor next operation
for line in open('data'):*use line*	File iterators read line by line
open('f.txt', encoding='latin-1')	Python 3.0 Unicode text files (strstrings)
open('f.bin', 'rb')	Python 3.0 binary bytes files (bytesstrings)

Reading from files.

Reading a file line by line using a "context manager" - with more examples later.

```
with open('data.txt') as file:
    for line in file:
        print(line, end='') # end='' omits the extra newline
```

- The open() function returns a new file object.
- The with statement that precedes it declares a block of statements (or context) where the file is going to be used.

Once control leaves this block, the file is automatically closed. If you don't use the with statement, the code would need to look like this:

```
file = open('data.txt')
for line in file:
    print(line, end='') # end='' omits the extra newline
file.close()
```

It's easy to forget the extra step of calling close() so it's better to use the with statement and have the file closed for you.

The for loop iterates line-by-line over the file until no more data is available.

If you want to read the file in its entirety as a string, use the read() method like this:

```
with open('data.txt') as file:
   data = file.read()
```

If you want to read a large file in chunks, give a size hint to the read() method as follows:

```
with open('data.txt') as file:
   while (chunk := file.read(10000)):
      print(chunk, end='')
```

The **:=** operator used in this example assigns to a variable and returns its value so that it can be tested by the while loop to break out. When the end of a file is reached, read() returns an empty string.

An alternate way to write the above function is using break:

```
with open('data.txt') as file:
   while True:
      chunk = file.read(10000)
      if not chunk:
         break
      print(chunk, end='')
```

Reading data typed interactively in the console.

To do that, use the input() function.

For example:

```
name = input('Enter your name : ')
print('Hello', name)
```

The input() function returns all of the typed text up to the terminating newline, which is not included.

Writing to files.

To make the output of a program go to a file, supply a file argument to the print() function:

```
with open('out.txt', 'wt') as out:
    while year <= numyears:
        principal = principal * (1 + rate)
        print(f'{year:>3d} {principal:0.2f}', file=out)
        year += 1
```

In addition, file objects support a write() method that can be used to write string data.

For example, the print() function in the previous example could have been written this way:

```
out.write(f'{year:3d} {principal:0.2f}\n')
```

Note: By default, files contain text encoded as UTF-8. If you're working with a different text encoding, use the extra encoding argument when opening the file. For example:

```
with open('data.txt', encoding='latin-1') as file:
    data = file.read()
```

Basic file operations

output = open(r'C:\spam', 'w')	Create output file ('w'means write)
input = open('data', 'r')	Create input file ('r'means read)
input = open('data')	Same as prior line ('r'is the default)
aString = input.read()	Read entire file into a single string
aString = input.read(N)	Read up to next Ncharacters (or bytes) into a string
aString = input.readline()	Read next line (including \nnewline) into a string
aList = input.readlines()	Read entire file into list of line strings (with \n)
output.write(aString)	Write a string of characters (or bytes) into file
output.writelines(aList)	Write all line strings in a list into file
print(value, …file='filename')	**Write to file "filename" instead of to the screen**
output.close()	Manual close (done for you when file is collected)
output.flush()	Flush output buffer to disk without closing any File.
seek(N)	Change file position to offset Nfor next operation
for line in open('data'):*use line*	File iterators read line by line
open('f.txt', encoding='latin-1')	Python 3.0 Unicode text files (strstrings)
open('f.bin', 'rb')	Python 3.0 binary bytes files (bytesstrings)

Problem:

Create this file (bears.txt) in your python directory:

```
Once upon a time
there were
three bears,
a poppa, a momma,
and a little baby bear!
```

Read the file line by line and print it out.

Answer:

```
f=open('bears.txt')
for i in f:
     print(i)
```

produces: Why the spaces between the lines?

```
>>>
Once upon a time

there were

three bears

a poppa, a momma,

and a little baby bear!
>>>
```

Problem:

Read the file into one string and print the string.

Answer:

```
f=open('bears.txt')
z=f.read()
print(z)
```

produces: What happened to the blank lines?

```
>>>
Once upon a time
there were
three bears
a poppa, a momma,
and a little baby bear!
>>>
```

Problem:

Read the file into a string s, separate the words in to a list (use ' ' to indicate the separator between words. Print out the list.

Answer:

```
f=open('bears.txt')
z=f.read()
z=z.split(' ')
print(z)
```

produces:

```
>>>
['Once', 'upon', 'a', 'time\nthere', 'were\nthree', 'bears\na', 'poppa,', 'a', '
momma,\nand', 'a', 'little', 'baby', 'bear!']
>>>
```

Note the '\n' , the newline character. This causes a like break.

but …

```
f=open('bears.txt')
z=f.read()
z=z.splitlines()
print(z)
```

produces:

```
>>>
['Once upon a time', 'there were', 'three bears', 'a poppa, a momma,', 'and a li
ttle baby bear!']
>>>
```

Notice that the newline characters are gone.

Problem:

Create a text file, 'grades.txt', with the following data.

```
Bob 78 98 67 77
Joan 78
Sally 90 97 77 56 88 98
```

Write a program to read this file and print out the students name followed by their average on all exams.

```
>>>
bob     Average=  80.00
joan    Average=  78.00
sally   Average=  84.33
>>>
```

Answer:

```
#Student averages
f=open('grades.txt')
for i in f:
  s=i.split()
  average=sum([int(s[i]) for i in range(1,len(s))])/(len(s)-1)
  print(format(s[0],'<7s'),'Average= ',format(average,'.2f'))
```

Problem:

Modify the above program so that it writes the result to a file called averages.

Answer:

Context Managers and the with statement

Resources are scarce. For example, the number of file handles or locks available on a system is usually fixed. If they are allocated and not properly returned to the system when they are no longer needed (for example when we finish reading a file), the system can degrade and ultimately fail. The with statement to the rescue!

The **with** statement in Python is a convenient way to open and close files, ensuring that the file is properly closed after the block of code is executed.

Here is an example of how the **with** statement is used to open a file:

```
with open("example.txt", "r") as f:
   # code to read from the file goes here
```

In this example, the **with** statement is used to open the file named "example.txt" in read-only mode. The **as** keyword is used to assign the file object to the variable **f**.

The code inside the **with** block can then read from the file using the **read()** method, for example:

```
with open("example.txt", "r") as f:
   contents = f.read()
   print(contents)
```

Once the code inside the **with** block has finished executing, the file will be automatically closed, even if an exception is raised. This ensures that the file is always closed properly, and helps to prevent errors related to files being left open.

What happens when an exception is thrown?

When an exception is thrown within the **with** block, the file will still be closed properly before the exception propagates up the call stack. This is because the **with** statement includes a built-in mechanism to ensure that the file is properly closed, even if an exception occurs.

For example, let's say we have the following code that tries to open a file that doesn't exist:

```
try:
   with open("nonexistent_file.txt", "r") as f:
      contents = f.read()
except FileNotFoundError:
   print("File not found.")
```

In this case, the code inside the **with** block will raise a **FileNotFoundError** exception, which will be caught by the **except** block. However, even though the exception was raised, the file will still be closed properly before the exception is handled.

Another example is when we attempt to write to a read-only file within a **with** block:

```
try:
    with open("example.txt", "r") as f:
        f.write("This won't work.")
except IOError:
    print("Unable to write to file.")
```

In this case, the code inside the **with** block will raise an **IOError** exception, since the file was opened in read-only mode and cannot be written to. However, once again, the file will still be closed properly before the exception is handled.

But with can be used for more cases that file processing.

The “with obj” statement allows the object obj to manage what happens when control-flow enters and exits the associated block of statements that follows.

When the with obj statement executes, it executes the method obj._ _enter_ _() to signal that a new context is being entered. When control flow leaves the context, the method obj._ _exit_ _(type,value,traceback) executes.

If no exception has been raised, the three arguments to _ _exit_ _() are all set to None. Otherwise, they contain the type, value, and traceback associated with the exception that has caused control-flow to leave the context. The _ _exit_ _() method returns True or False to indicate whether the raised exception was handled or not (if False is returned, any exceptions raised are propagated out of the context).

The with obj statement accepts an optional as var specifier. If given, the value returned by obj._ _enter_ _() is placed into var. It is important to emphasize that obj is not necessarily the value assigned to var.

When can the with statement be used?

The with statement only works with objects that support the context management protocol (the _ _enter_ _() and _ _exit_ _() methods). User-defined classes can implement these methods to define their own customized context-management. Here is a simple example:

```
class ListTransaction(object):
    def __init__(self,thelist):
        self.thelist = thelist
    def __enter__(self):
        self.workingcopy = list(self.thelist)
        return self.workingcopy
    def __exit__(self,type,value,tb):
        if type is None:
            self.thelist[:] = self.workingcopy
        return False
```

This class allows one to make a sequence of modifications to an existing list. However, the modifications only take effect if no exceptions occur. Otherwise, the original list is left unmodified. For example:

```
items = [1,2,3]
with ListTransaction(items) as working:
    working.append(4)
    working.append(5)
print(items)       # Produces [1,2,3,4,5]

try:
    with ListTransaction(items) as working:
        working.append(6)
        working.append(7)
        raise RuntimeError("We're hosed!")
except RuntimeError:
    pass
print(items)   # Produces [1,2,3,4,5]
```