1 Lost on the Moon

Your spaceship has just crashed on the moon. You were scheduled to rendezvous with a mother ship 200 miles away on the lighted surface of the moon, but the rough landing has ruined your ship and destroyed all the equipment on board except for the 15 items listed below.

Your crew’s survival depends on reaching the mother ship, so you must choose the most critical items available for the 200-mile trip. Your task is to rank the 15 items in terms of their importance for survival. Place a number 1 by the most important item, number 2 by the second most important, and so on, through number 15, the least important.

| Item | Your Rank (1) | Group’s Rank (2) | NASA’s Rank (3) | |(3) − (1)| |(3) − (2)| |
|------|---------------|------------------|----------------|----------|----------|----------|
| Box of matches | | | | | | |
| Food concentrate | | | | | | |
| 50 feet of nylon rope | | | | | | |
| Parachute silk | | | | | | |
| Solar-powered portable heating unit | | | | | | |
| Two .45 caliber pistols | | | | | | |
| One case of dehydrated milk | | | | | | |
| Two 100-pound tanks of oxygen | | | | | | |
| Stellar map (of the moon’s constellations) | | | | | | |
| Self-inflating life raft | | | | | | |
| Magnetic compass | | | | | | |
| 5 gallons of water | | | | | | |
| Signal flares | | | | | | |
| First-aid kit containing injection needles | | | | | | |
| Solar-powered FM receiver-transmitter | | | | | | |
| **Total** | | | | | | |
Error points are the absolute difference between your rankings and NASA’s (disregard plus or minus signs).

- 0 - 25: excellent
- 26 - 32: good
- 33 - 55: fair
- 56 - 70: oops
- 71 - 112: oh well

<table>
<thead>
<tr>
<th>Item</th>
<th>NASA’s Reasoning</th>
<th>NASA’s Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box of matches</td>
<td>No oxygen to sustain flame, virtually worthless</td>
<td>15</td>
</tr>
<tr>
<td>Food concentrate</td>
<td>Efficient means of supplying energy requirements</td>
<td>4</td>
</tr>
<tr>
<td>50 feet of nylon rope</td>
<td>Useful in scaling cliffs, tying injured together</td>
<td>6</td>
</tr>
<tr>
<td>Parachute silk</td>
<td>Protection from sun’s rays</td>
<td>8</td>
</tr>
<tr>
<td>Solar-powered portable heating unit</td>
<td>Not needed unless on dark side</td>
<td>13</td>
</tr>
<tr>
<td>Two .45 caliber pistols</td>
<td>Possible means of self-propulsion</td>
<td>11</td>
</tr>
<tr>
<td>One case of dehydrated milk</td>
<td>Bulkier duplication of food concentrate</td>
<td>12</td>
</tr>
<tr>
<td>Two 100-pound tanks of oxygen</td>
<td>Most pressing survival need</td>
<td>1</td>
</tr>
<tr>
<td>Stellar map (of the moon’s constellations)</td>
<td>Primary means of navigation</td>
<td>3</td>
</tr>
<tr>
<td>Self-inflating life raft</td>
<td>CO$_2$ bottle in military raft may be used for propulsion</td>
<td>9</td>
</tr>
<tr>
<td>Magnetic compass</td>
<td>Magnetic field on moon is not polarized; worthless for navigation</td>
<td>14</td>
</tr>
<tr>
<td>5 gallons of water</td>
<td>Replacement for tremendous liquid loss on lighted side</td>
<td>2</td>
</tr>
<tr>
<td>Signal flares</td>
<td>Distress signal when mother ship is sighted</td>
<td>10</td>
</tr>
<tr>
<td>First-aid kit containing injection needles</td>
<td>Needles for vitamins, medicines, etc., will fit special aperture in NASA space suits</td>
<td>7</td>
</tr>
<tr>
<td>Solar-powered FM receiver-transmitter</td>
<td>For communication with mother ship; but FM requires line-of-sight transmission and short ranges</td>
<td>5</td>
</tr>
</tbody>
</table>
2 Python basics

Primitive expressions

A primitive expression requires only a single evaluation step. Literals, such as numbers and strings, evaluate to themselves. Names require a single lookup step (see the Assignment statements section below).

```python
>>> 2
2
>>> 'Hello World!'
'Hello World!'
```

Arithmetic expressions

Arithmetic expressions in Python are very similar to ones we’ve seen in other math contexts. They involve binary arithmetic operators (+, -, *, /, //, %, and **) and follow PEMDAS rules.

```python
>>> 6 + 2 * 5
16
>>> 9 // 2  # Floor division (rounding down)
4
>>> 9 % 2  # Modulus (remainder of 9 // 2)
1
>>> (3 + 2) * 4 // 3
6
>>> 4 ** 3  # Exponent
64
```

Assignment statements

An assignment statement assigns a certain value to a variable name.

\[
\text{Name} = \text{Expression}
\]

To execute an assignment statement:

1. Evaluate the expression on the right-hand-side of the statement to obtain a value.
2. Bind the value to the name on the left-hand-side of the statement.

Let’s try to assign the primitive value 6 to the name a, and subsequently do a lookup on a.

```python
>>> a = 6
>>> a
6
```
4 Introduction and Functions

Now, let’s reassign a to another value. This time, let’s use a more complex expression. Note that the name is bound to the value, not the expression!

```python
>>> a = (3 + 5) // 2
>>> a
4
```

Questions

2.1 What would Python display?

```python
>>> 3 + 4 ** 2
19

>>> a = 6 + 2 * 4
>>> a
14

>>> b = (2 + 2) * 2 + 3 % 2
>>> b
9

>>> a + 2 * b
32

>>> b += a  # Equivalent to b = b + a
>>> a
14
>>> b
23
```
3 Functions

Writing and calling functions is a crucial part in managing complexity when programming.

Functions allow us to apply a series of statements to some arguments to produce a return value. For example, let’s take a look at the built-in abs function:

```plaintext
>>> abs(123)
123
>>> abs(-2000)
2000
```

This function takes in one argument, a number, and returns its absolute value. Since this is a built-in function, we don’t know what statements were executed to obtain this output. The expressions above are known as call expressions.

Calling functions

A **call expression** applies a function to 0 or more arguments and evaluates to the function’s return value.

```
add ( 2, 3 )
```

To evaluate a function call:

1. Evaluate the operator, which should evaluate to a function.
2. Evaluate the operands from left to right to get the values of the arguments.
3. Apply the function (the value of the operator) to the arguments (the values of the operands) to obtain the return value.

If the operator or an operand is itself a call expression, then these steps are applied in order to evaluate it.

Defining functions

The **def** statement defines functions.

```python
def square(x):
    return x * x
```

When a **def** statement is executed, Python creates a binding from the name (e.g. **square**) to a function. The names in parentheses are the function’s **parameters** (in this case, **x** is the only parameter). When the function is called, the **body** of the function is executed (in this case, **return x * x**).
Questions

3.1 Consider the function below.

```python
def foo(x, y):
    y = y + 4
    x = y / 2
    return x * y
```

How many arguments does this function take in, and what type should they be?

The `foo` function takes in two arguments; the second has to be a number, and though it seems like the first should also be a number, it can be anything, because the first parameter gets reassigned in the second line!

Consider the call expression `foo(5, 1 + 3)`. What are `x` and `y` bound to inside the body of the function during this call?

The parameter `x` is bound to 5 and the parameter `y` is bound to 4 (the result of `1 + 3`).

What does the call expression `foo(5, 4)` return?

32. First, `y` is reassigned to 8. Then, `x` is reassigned to 4. Finally, the result of `4 * 8` is returned.

What about `foo(10, 4)`?

The output would still be 32. Notice that the first argument will never affect our result because `x` gets reassigned in the second line.

3.2 Now, let’s practice defining functions. In the space below, write a function called `square_diff` that takes in two integer arguments and returns the result of squaring the difference between the arguments. You may name the parameters whatever you’d like. Be sure to use proper Python syntax!

```python
>>> square_diff(4, 1)
9
>>> square_diff(2, 7)
25
```

```python
def square_diff(a, b):
    diff = a - b
    return diff * diff
```