Bug # 1	Parentheses in creation of list of lists with list comprehension
Why it is a Bug	The comment calls for a list of lists, not a list of tuples
When Triggered	The bug is triggered when the list is populated with empty tuples
How I Found it	Reading the comments and the code
Exception Type	None
Type of Error	Logical
Bug Fix Line #	24
Bug Fix Description	I replaced the parentheses with brackets to create a list of lists as specified on line 23
Excp. Screenshot	None

Bug # 2	Y value indicates the same value as the x value
Why it is a Bug	In order to import the points, the y value has to be indicated appropriately
When Triggered	It is triggered on the first pass of the parent for loop
How I Found it	Reading the code, I realized the points aren't parsed correctly because they both indicated index [0]
Exception Type	None
Type of Error	Logical
Bug Fix Line #	34
Bug Fix Description	I changed the y value to indicate point[1] instead of point[0]
Excp. Screenshot	None

Bug # 3	Index of cluster index used for point index instead of the cluster index value
Why it is a Bug	The for loop would append the points according to the number of cluster indexes in order of the points list, instead of looking through the points list for the correct cluster value
When Triggered	It's triggered when the parent for loop is executed for the first time
How I Found it	Thinking about the code line-by-line, I had a hunch it wasn't right. Looking carefully at what it was doing, I saw that it was indicating the wrong centroids
Exception Type	None
Type of Error	Logical
Bug Fix Line #	45
Bug Fix Description	I added a dummy variable to store the index_value of the centroid according to the list of centroids, and then changed to the index of points[index_value] so the appropriate points would be pulled from the points list
Excp. Screenshot	None

Bug # 4	Reverse indexing of point deletion
Why it is a Bug	There is no need to iterate in reverse order, it would not prevent the points to be shifted by 1 either way – the operation doesn't cause that
When Triggered	Triggered in running the for loop with negative indexing
How I Found it	Looking at the comments and thinking about the algorithm, the points are not "shifted" at all by deleting members of the list, reversely or not
Exception Type	None
Type of Error	Logical
Bug Fix Line #	50
Bug Fix Description	The negative index on the cluster_index list was removed, and the associated comment
Excp. Screenshot	None

Bug # 5	Similar to Bug#3, the value for the cluster_indexes was not indicated, the index was used instead
Why it is a Bug	This would delete the wrong points
When Triggered	Triggered when the for loop executes the deletion code
How I Found it	Thinking again about what the code is doing, and the comment, I saw the same bug as #3
Exception Type	None
Type of Error	Logical
Bug Fix Line #	52
Bug Fix Description	I added my dummy variable and fixed the index of the points deleted
Excp. Screenshot	None

Bug # 6	Missing parentheses on x value calculation
Why it is a Bug	Without parentheses the x value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the x value calculation, before the squaring
Excp. Screenshot	None

Bug # 7	Missing parentheses on x value calculation
Why it is a Bug	Without parentheses the x value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the x value calculation, before the squaring
Excp. Screenshot	None

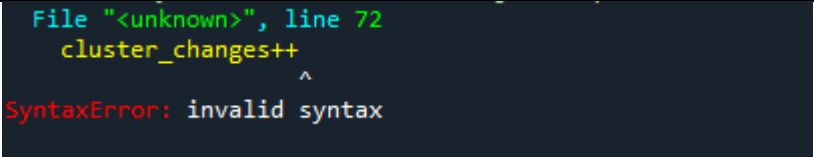| Bug # 8	Missing parentheses on x value calculation
Why it is a Bug	Without parentheses the x value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the x value calculation, before the squaring
Excp. Screenshot	None

Bug # 9	Missing parentheses on x value calculation
Why it is a Bug	Without parentheses the x value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the x value calculation, before the squaring
Excp. Screenshot	None

Bug # 10	Missing parentheses on y value calculation
Why it is a Bug	Without parentheses the y value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the y value calculation, before the squaring
Excp. Screenshot	None

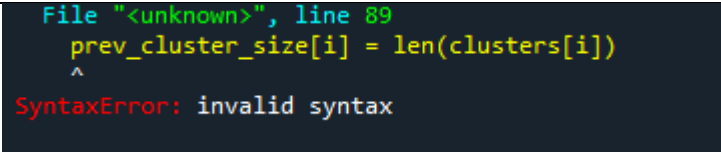| Bug # 11	Missing parentheses on y value calculation
Why it is a Bug	Without parentheses the y value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the y value calculation, before the squaring
Excp. Screenshot	None

Bug # 12	Missing parentheses on y value calculation
Why it is a Bug	Without parentheses the y value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the y value calculation, before the squaring
Excp. Screenshot	None

Bug # 13	Missing parentheses on y value calculation
Why it is a Bug	Without parentheses the y value is not squared, the point value is squared
When Triggered	Upon the first iteration of the parent for loop, and the first iteration of the child for loop, the code is executed
How I Found it	Thinking about the math, and the Pythagorean Theorem, I noticed the error
Exception Type	None
Type of Error	Logical
Bug Fix Line #	59-62
Bug Fix Description	Added parentheses around the y value calculation, before the squaring
Excp. Screenshot	None

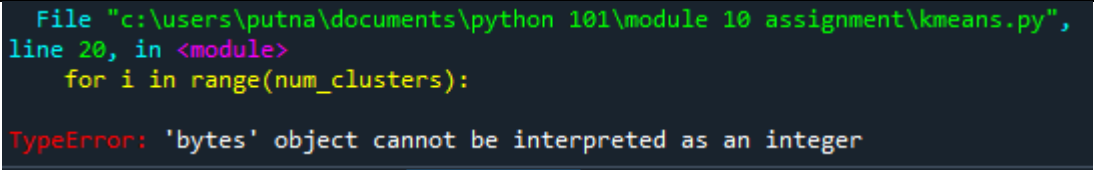| Bug # 14	Wrong indices in the cluster append logic
Why it is a Bug	There are four clusters 0, 1, 2, 3 not 1, 2, 3, 4 so this would result in an incomplete sort by the if control structure
When Triggered	This is triggered for every point by the child point loop inside of the parent iterations loop
How I Found it	Thinking about the completeness of the code, I realized it would not work correctly and also it doesn't correspond to the d1, d2, d3, d4 logic
Exception Type	None
Type of Error	Logical
Bug Fix Line #	65-72
Bug Fix Description	I put in the correct indices, but I also noticed that due to this structure, and the choice of distance calculation, the code would not work with a variable K value
Excp. Screenshot	None

Bug # 15	Here the intention is to increment cluster_changes but there is a typo
Why it is a Bug	There must be a space between the operator and the variable, and also there is no unary increment operator in Python, += 1 must be used
When Triggered	This is the first exception triggered when running the code
How I Found it	I ran the code for the first time and saw this error
Exception Type	SyntaxError: invalid syntax because it is taken as a variable without and operation
Type of Error	Lexical
Bug Fix Line #	77 was 72
Bug Fix Description	I added a space after the variable name and changed the operator to a valid one
| **Excp. Screenshot** | ```
  File "<unknown>", line 72
    cluster_changes++
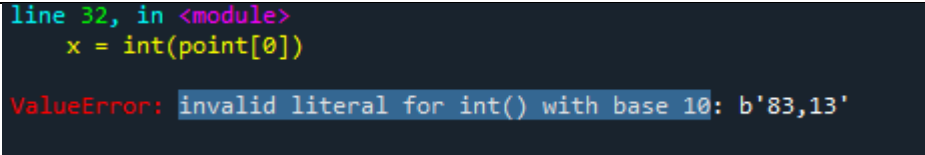                    ^
SyntaxError: invalid syntax
``` |

Bug # 16	Total_x and total_y variables not initialized
Why it is a Bug	Summing the x and y coordinates would not work because the variables aren't initialized and reset for each cluster
When Triggered	This is triggered first when the summation code runs
How I Found it	Thinking about the comments and the code, I realized it was missing something, also I had a hunch a semantic error was coming
Exception Type	None
Type of Error	Semantic
Bug Fix Line #	87-88
Bug Fix Description	Initialized the variables within the for loop to have 0 starting values and these values are refreshed as 0 for each cluster to provide the right totals
Excp. Screenshot	None

Bug # 17	A forgotten parentheses makes the interpreter expect one
Why it is a Bug	The len() function is not closed and so the execution fails
When Triggered	When running the code this is thrown, indicating line 89 but the problem starts on 86
How I Found it	There was a flag in the debugger, and I ran the code and saw an exception
Exception Type	SyntaxError: invalid syntax
Type of Error	Syntax
Bug Fix Line #	92-95 was 86-89
Bug Fix Description	I added a parentheses to complete the len() function
| **Excp. Screenshot** | ```
File "<unknown>", line 89
    prev_cluster_size[i] = len(clusters[i])
    ^
SyntaxError: invalid syntax
``` |
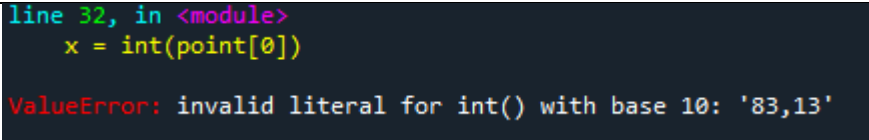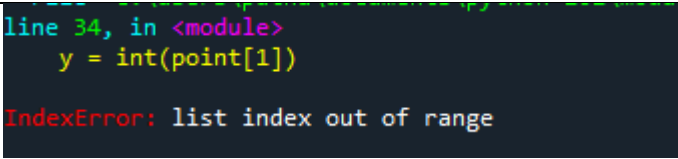
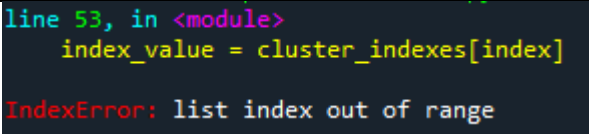| Bug # 18	Control statement missing an alternative
Why it is a Bug	The logic of the program requires that the loop breaks when there is no cluster change
When Triggered	When the cluster change if statement is triggered the break is triggered
How I Found it	Thinking about what's needed for the program I saw it missing
Exception Type	None
Type of Error	Semantic
Bug Fix Line #	73
Bug Fix Description	I added an else: condition to the for loop, otherwise the clusters get cleared when the algorithm converges. This way it breaks the parent loop and prints as soon as the clusters remain unchanged
Excp. Screenshot	None

Bug # 19	The bytes object for the number of clusters is not converted to an integer
Why it is a Bug	The code calls for an integer to use the range() function
When Triggered	After cleaning up the rest of the code, if you run it an exception is triggered back a t the top, not sure why
How I Found it	I tried to run the code after going through it once
Exception Type	TypeError: 'bytes' object cannot be interpreted as an integer
Type of Error	Semantic
Bug Fix Line #	18
Bug Fix Description	I added an int() conversion to num_clusters
| Excp. Screenshot | ```
    File "c:\users\putna\documents\python 101\module 10 assignment\kmeans.py",
line 20, in <module>
        for i in range(num_clusters):

TypeError: 'bytes' object cannot be interpreted as an integer
``` |

Bug # 20	The point is still a bytes object
Why it is a Bug	Much like the last bug, the bytes object needs to be converted to an integer to be used by the range() function, I noticed the file was opened in "rb" mode
When Triggered	After fixing the last bug and running the code an exception pops up, I'm not sure why it wasn't triggered the first time I ran the code
How I Found it	I keep trying to run the code after going through it once, now spotting more bugs, here the file is opened in the wrong mode
Exception Type	TypeError: invalid literal for int() with base 10: b'83,13'
Type of Error	Semantic
Bug Fix Line #	33 and 9 was 32 and 9
Bug Fix Description	I changed the read mode to "r" to get strings in
Excp. Screenshot	

```
line 32, in <module>
    x = int(point[0])

ValueError: invalid literal for int() with base 10: b'83,13'
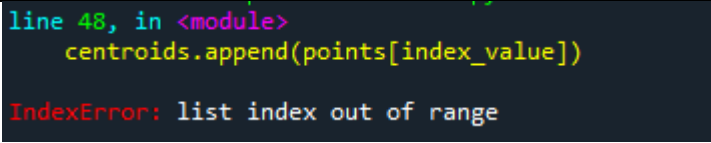```

| | |
|---|---|
| **Bug # 21** | The string is not being split because it's missing an argument |
| **Why it is a Bug** | The points are provided in a comma delimited format, so they need to be split according to the comma |
| **When Triggered** | When trying to run the code an exception is raised early in the code, line 32 |
| **How I Found it** | I fixed the read mode, and it still didn't run, an exception was raised |
| **Exception Type** | ValueError: invalid literal for int() with base 10: '83'13' |
| **Type of Error** | Semantic |
| **Bug Fix Line #** | 31 was 32 |
| **Bug Fix Description** | I added the comma to the split argument |
| **Excp. Screenshot** | ```
line 32, in <module>
    x = int(point[0])

ValueError: invalid literal for int() with base 10: '83,13'
``` |

Bug # 22	The input file contains improper values
Why it is a Bug	In this case a O letter is substituted for a 0
When Triggered	When running the code as the points list is constructed the exception is thrown
How I Found it	I ran the code to find the input error
Exception Type	ValueError: invalid literal for int() with base 10:P '4O'
Type of Error	Input Error
Bug Fix Line #	33 was 32
Bug Fix Description	I used a try except block the skip the line when it encounters ValueErrors
| **Excp. Screenshot** | ```
line 32, in <module>
    x = int(point[0])

ValueError: invalid literal for int() with base 10: '4O'
``` |

Bug # 23	The input file contains improper values
Why it is a Bug	The points are x and y pairs. There can contain errors where the comma is missing. This is seen by Python as one x value
When Triggered	When appending to the list, an Error is thrown
How I Found it	I keep running the code to find out if the pieces of the code are working. I put in a print statement to look at the list of points and then I checked the input file
Exception Type	IndexError: list out of range`
Type of Error	Input Error
Bug Fix Line #	37
Bug Fix Description	I added to the try except block to skip lines with errors of this type
Excp. Screenshot	

```
line 34, in <module>
    y = int(point[1])

IndexError: list index out of range
```

Bug # 24	Missing range() function for cluster_indexes
Why it is a Bug	The list index is not specified properly so the for loop doesn't work
When Triggered	When running through the code the error is thrown
How I Found it	Running the code sequentially
Exception Type	IndexError: list index out of range
Type of Error	Semantic
Bug Fix Line #	51 was 53
Bug Fix Description	I added range(len()) to the iterable
| Excp. Screenshot | ```
line 53, in <module>
    index_value = cluster_indexes[index]

IndexError: list index out of range
``` |

Bug # 25	There was a missing function call to range(len())
Why it is a Bug	The for loop doesn't work without it
When Triggered	When running the code it occurs in order
How I Found it	I ran the code
Exception Type	IndexError: list index out of range
Type of Error	Semantic
Bug Fix Line #	45 was 48
Bug Fix Description	I added range(len()) to make it work
| **Excp. Screenshot** | ```
line 48, in <module>
    centroids.append(points[index_value])

IndexError: list index out of range
``` |

Screenshot of Output

```
Initial COVID-19 Patients: [[30, 45], [91, 45], [54, 78], [12, 5]]

Iterations to achieve stability: 4

Final Centroids:
[30, 45]
[91, 45]
[54, 78]
[12, 5]

Number of patients in Cluster 0: 29
[[5, 58], [33, 30], [37, 61], [22, 58], [2, 56], [5, 53], [40, 41], [46, 46],
[34, 38], [56, 17], [38, 45], [37, 57], [7, 44], [16, 47], [52, 12], [17, 71],
[18, 75], [19, 61], [16, 33], [58, 32], [48, 24], [41, 49], [23, 71], [56, 15],
[31, 67], [2, 34], [42, 27], [1, 91], [43, 50]]

Number of patients in Cluster 1: 22
[[83, 13], [80, 18], [77, 16], [93, 73], [81, 40], [78, 16], [89, 26], [91, 45],
[88, 32], [92, 34], [99, 15], [86, 57], [86, 36], [71, 21], [78, 67], [88, 71],
[89, 16], [97, 35], [91, 7], [98, 24], [93, 40], [81, 32]]

Number of patients in Cluster 2: 31
[[37, 95], [40, 64], [40, 96], [64, 91], [97, 99], [51, 80], [42, 86], [40, 74],
[53, 82], [11, 95], [41, 95], [47, 97], [22, 81], [65, 85], [44, 62], [10, 87],
[13, 85], [78, 81], [54, 78], [58, 83], [43, 67], [26, 97], [81, 83], [30, 97],
[79, 76], [44, 92], [52, 100], [64, 99], [70, 75], [52, 67], [71, 76]]

Number of patients in Cluster 3: 14
[[0, 27], [34, 7], [21, 23], [36, 9], [19, 12], [39, 2], [12, 5], [15, 10], [6,
18], [18, 2], [31, 8], [20, 10], [1, 27], [24, 0]]
```