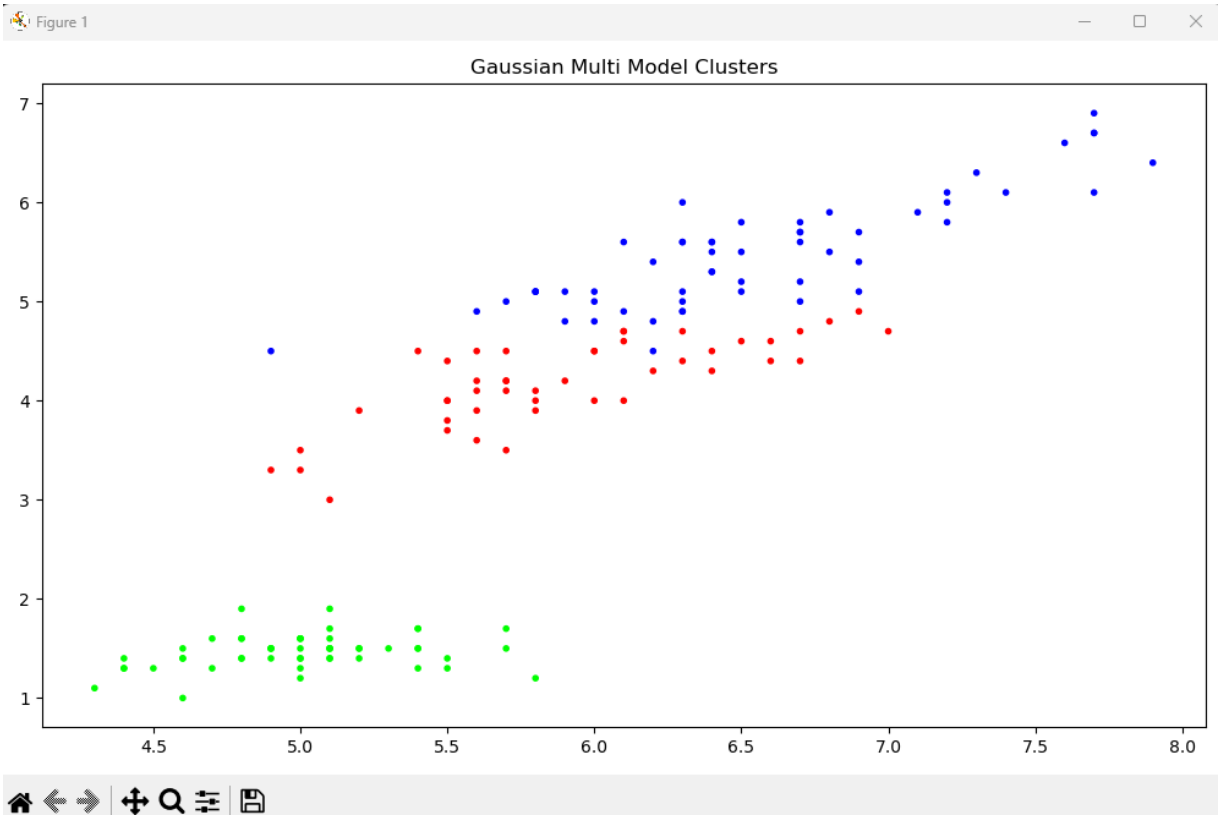
PROBLEM # 1

GMM_MGD_iris_1174066.py OUTPUTS




```
 [9.94247763e-001 5.75223739e-003 3.92691711e-205]
 [1.00000000e+000 2.57872741e-014 2.26937490e-173]
 [7.88486794e-001 2.11513206e-001 1.10386481e-115]
 [9.99971189e-001 2.88113376e-005 3.81184609e-140]
 [1.00000000e+000 1.43776444e-014 1.36200660e-213]
 [1.00000000e+000 2.88272186e-013 2.08485457e-178]
 [9.97721911e-001 2.27808921e-003 2.26670169e-144]
 [9.94637454e-001 5.36254639e-003 2.47676751e-110]
 [9.99999933e-001 6.69673938e-008 4.34353662e-156]
 [1.00000000e+000 8.67127410e-017 4.11683595e-183]
 [1.00000000e+000 2.92398529e-014 4.90573275e-153]
 [9.99999908e-001 9.20788897e-008 1.37244704e-131]
 [1.00000000e+000 3.26952213e-012 3.06163663e-192]
 [1.00000000e+000 1.69089024e-017 2.36538744e-192]
 [1.00000000e+000 2.44324430e-015 2.94602736e-158]
 [9.99999998e-001 1.89664147e-009 3.77666948e-131]
 [9.99998960e-001 1.03988588e-006 2.74839003e-140]
 [1.00000000e+000 1.15192662e-010 7.55693259e-162]
 [9.98408255e-001 1.59174505e-003 6.53773487e-124]]
[0.36769331 0.29897336 0.33333333]
[2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
accuracy = 96.66666666666667
Press any key to continue . . .
```

GMM_SKL_1174066 _iris_data.py OUTPUTS

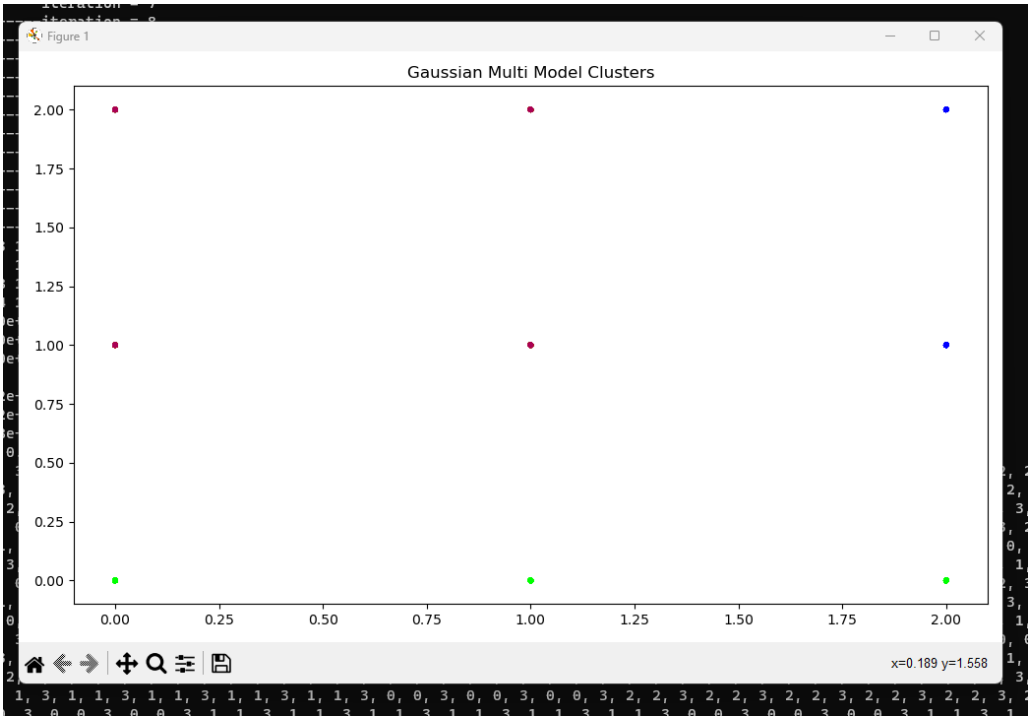
```
[[5.91697517 2.77803998 4.20523542 1.29841561]
 [5.006      3.418      1.464      0.244     ]
 [6.54632887 2.94943079 5.4834877  1.98716063]]
[0.30118609 0.33333333 0.36548058]
[[[0.27550587 0.09663458 0.18542939 0.05476915]
  [0.09663458 0.09255531 0.09103836 0.04299877]
  [0.18542939 0.09103836 0.20227635 0.0616792 ]
  [0.05476915 0.04299877 0.0616792  0.03232217]]

 [[0.121765   0.098292   0.015816   0.010336  ]
  [0.098292   0.142277   0.011448   0.011208  ]
  [0.015816   0.011448   0.029505   0.005584  ]
  [0.010336   0.011208   0.005584   0.011265  ]]

 [[0.38741443 0.09223101 0.30244612 0.06089936]
  [0.09223101 0.11040631 0.08386768 0.0557538 ]
  [0.30244612 0.08386768 0.32595958 0.07283247]
  [0.06089936 0.0557538  0.07283247 0.08488025]]]
-1.2067147814234245
[1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 0 2 0 2 0
 0 0 0 2 0 0 0 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 2 2 2 2 2 2 2 2 2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 2 2]
accuracy = 96.66666666666667
Press any key to continue . . .
```

CONCLUSION

The comparison between custom Gaussian Mixture Model (GMM) and scikit-learn's Model demonstrates equivalent accuracy in clustering tasks, affirming the effectiveness of cutsome model implementation. This parity underscores the reliability and robustness of this custom GMM model, showcasing its capability to yield results on par with established libraries like scikit-learn.

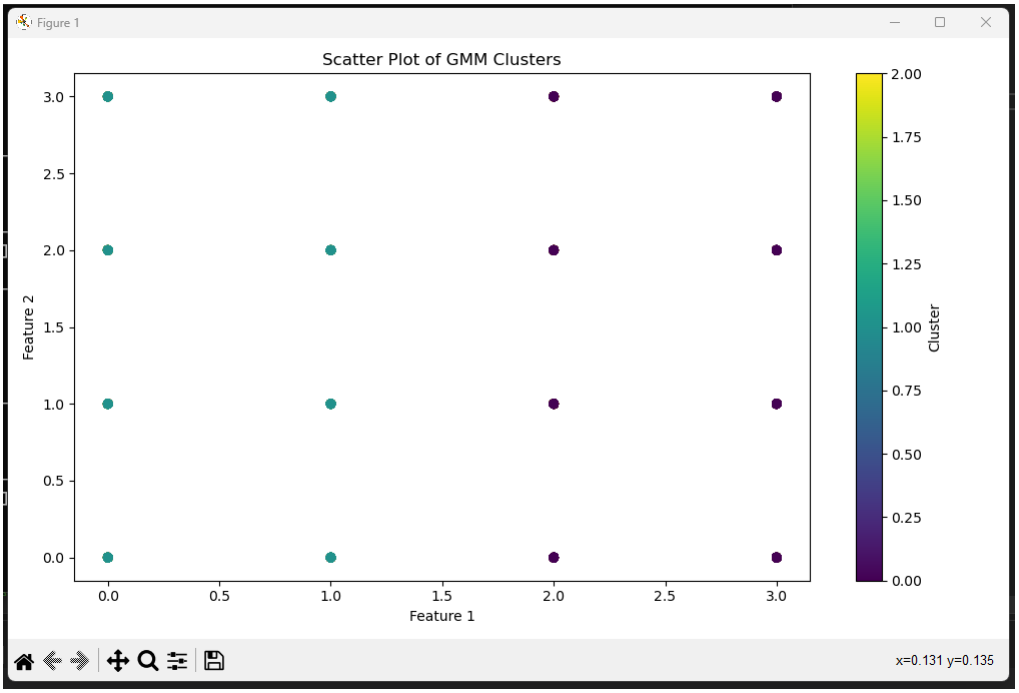
PROBLEM # 2

GMM_MGD_car_evaluation_dataset_1174066.py OUTPUTS




```
 [9.99923372e-01 7.66262597e-05 1.40171047e-09 0.00000000e+00]
 [7.87922998e-02 1.80882392e-06 3.68122520e-11 9.21205891e-01]]
[0.23109885 0.22305872 0.22108811 0.32475432]
[2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2
, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1,
3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1,
 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3
, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3,
0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0,
 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2
, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1,
0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3,
 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2
, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0,
3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2,
 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3
, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3,
2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2,
 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0
, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1,
0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3,
 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1
, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1,
3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2,
 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 1, 1, 3, 1, 1, 3
, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 0, 0, 3,
1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0, 3, 2, 2, 3, 2, 2, 3, 2, 2, 3, 2,
 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 1, 1, 3, 0, 0, 3, 0, 0, 3, 0, 0
accuracy = 33.35263462651998
Press any key to continue . . .
```

GMM_SKL_1174066 _car_data.py OUTPUTS




```
 [ 9.04743516e-05  2.14996398e-04  4.42294019e-04 -1.37967483e-04
   6.66677403e-01  2.30868223e-17]
 [-2.21633494e-17 -5.91022652e-17 -7.36007896e-16  1.10816747e-17
   2.58572410e-17  6.66649270e-01]]

[[ 1.05664121e+00  2.17362415e-02 -7.99035109e-02  3.18362945e-03
  -3.18362945e-03 -1.03943811e-16]
 [ 2.17362415e-02  1.24629703e+00  1.65840586e-02  2.07773112e-03
  -2.07773112e-03  7.53418231e-17]
 [-7.99035109e-02  1.65840586e-02  2.42060999e-01 -5.70023408e-04
   5.70023408e-04 -3.53688003e-16]
 [ 3.18362945e-03  2.07773112e-03 -5.70023408e-04  6.66247033e-01
   1.44814287e-03 -1.11617516e-17]
 [-3.18362945e-03 -2.07773112e-03  5.70023408e-04  1.44814287e-03
   6.66247033e-01  2.79043789e-18]
 [-1.03420604e-16  6.69705094e-17 -3.56478441e-16 -8.37131367e-18
  -2.79043789e-18  6.67501707e-01]]]
-8.059803868415694
[2 2 2 ... 1 1 1]
Accuracy = 55.99305153445281
Press any key to continue . . .
```

CONCLUSION

Despite the custom GMM model achieving an accuracy of 33%, notably lower than the scikit-learn (SKL) model's 56%, its implementation incorporates regularization and tolerance parameters to mitigate overfitting and improve convergence during the expectation-maximization process. The inclusion of regularization aids in preventing covariance matrices from becoming singular, while the tolerance parameter enhances stability by halting iterations once the changes in model parameters become negligible, contributing to the model's reliability and robustness.