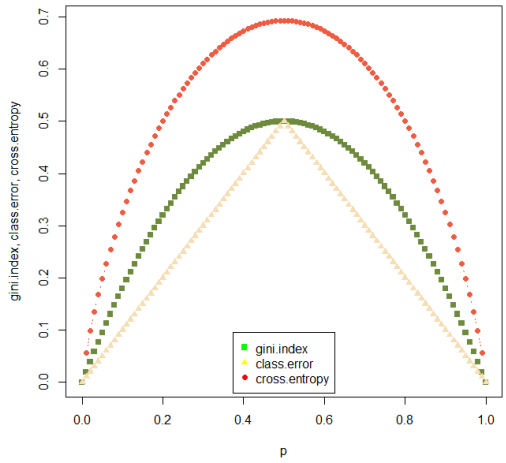
Homework 4

Sean Eva

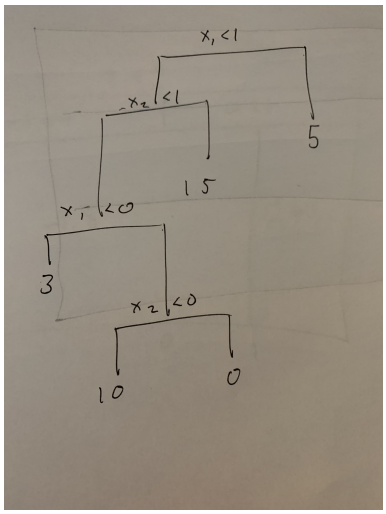
April 2022

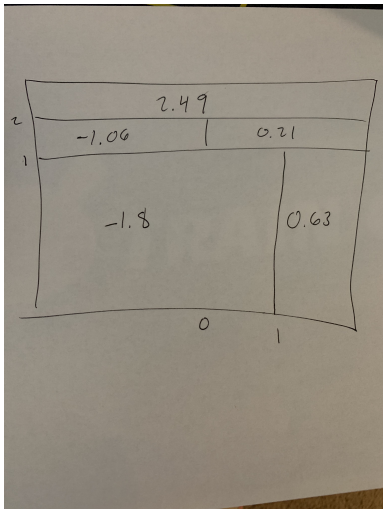
1 Theoretical Problems



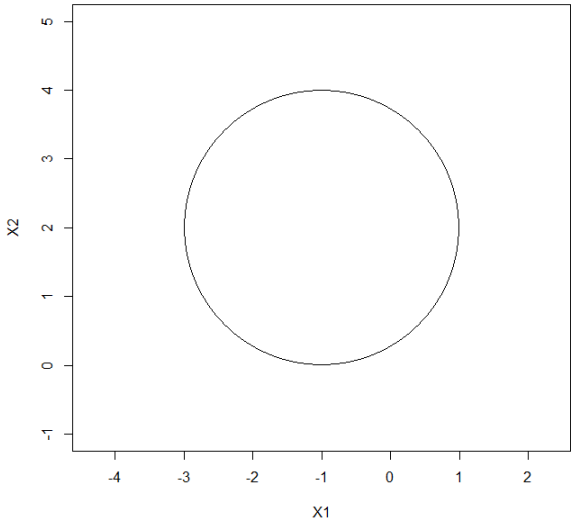
8.4: 3.

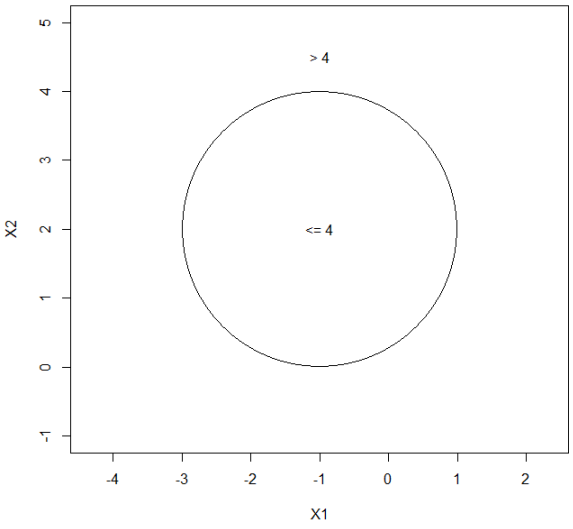
8.4: 4. (a)



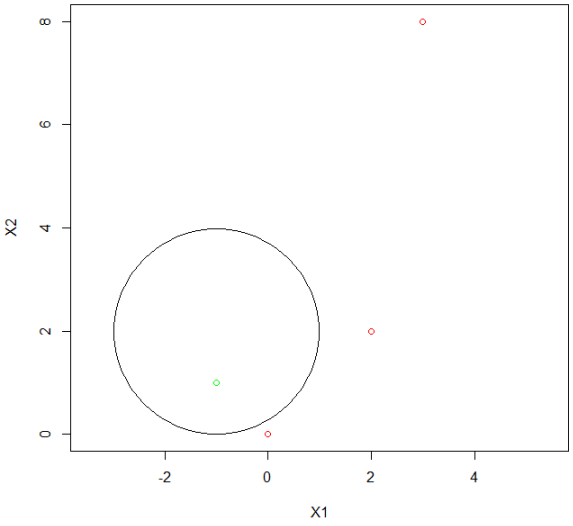
(b) 

8.4: 5. Using the majority vote method, we would find that there are 6 votes for red and only 4 votes for green which would lead us to conclude that the class if red. If we use an average probability method we would find an average $\mathbb{P}(\text{Class is Red}|X) = 0.45$ which would lead us to conclude that the class is green.

9.7: 2. (a) 

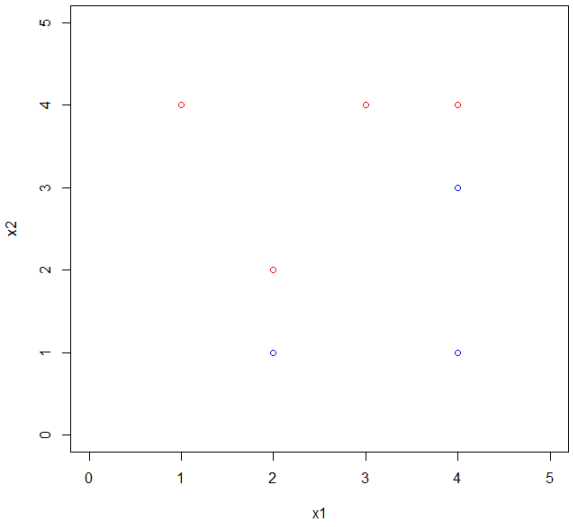


(b)



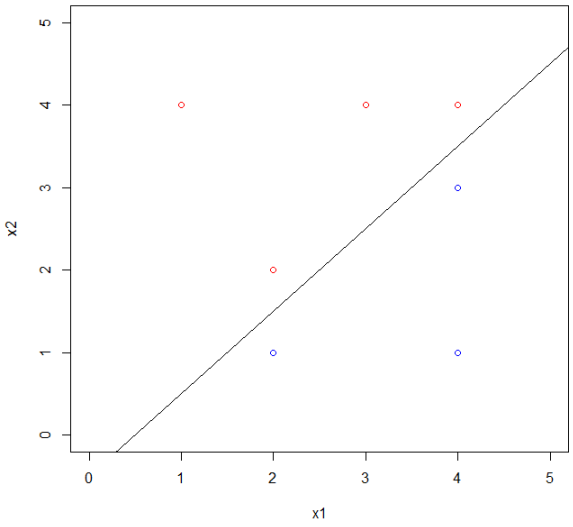
(c)

(d) If we expand the equation of the decision boundary $(1 + X_1)^2 + (2 - X_2)^2 = 4$ which expands to $X_1^2 + X_2^2 + 2X_1 - 4X_2 + 1 = 0$ which is linear in terms of $X_1, X_1^2, X_2, \text{and} X_2^2$.

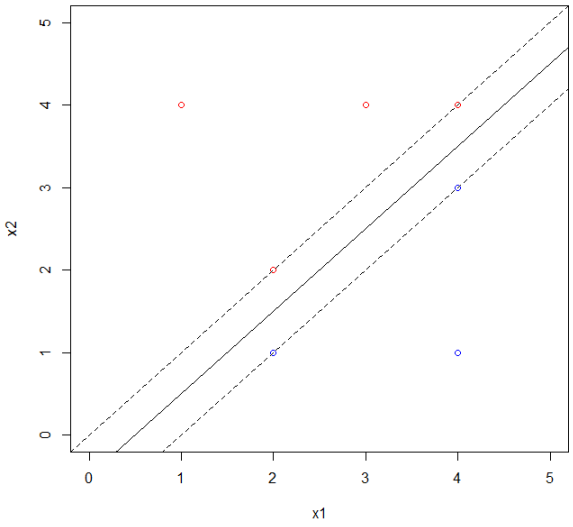


9.7: 3. (a)

(b) As shown in the plot, the optimal separating hyperplace has to be between the observations $(2, 1)$ and $(2, 2)$, and between the observations $(4, 3)$ and $(4, 4)$. So it is a line that passes through the points $(2, 1.5)$ and $(4, 3.5)$ which is the equation $X_1 - X_2 - 0.5 = 0$.



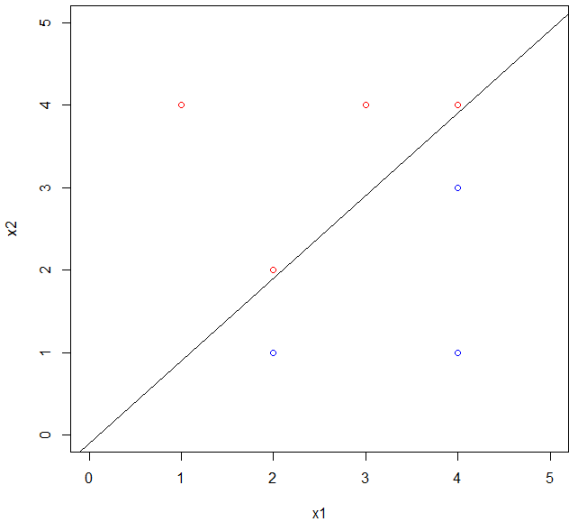
(c) The classification rule is to classify as red if $X_1 - X_2 - 0.5 < 0$ and to classify as blue otherwise.



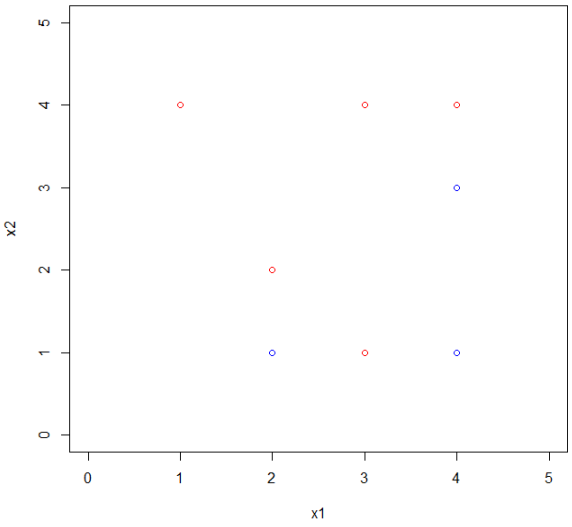
(d)

(e) The support vectors are the points $(2, 1), (2, 2), (4, 3)$, and $(4, 4)$.

(f) By examining the plot, it is easy to note that if we moved the observation $(4, 1)$, we would not change the maximal margin hyperplane because we did not classify it as a support vector.



(g)



(h)

2 Programming

1. (a) The test mean squared error 22.863431372549016
   (b) When we performed this using $m = 6tom = 25$ we noticed the original tree expand. However, when we moved to $m = 100$ the tree did not grow a substantial amount.
   (c) The error rate is about 19.2%.
   (d) Sorry ran out of time.
2. (a) In code.
   (b) A cost of 1 seems to perform best.
   (c) For a polynomial kernel, the lowest cross-validation error is obtained for a degree of 2 and a cost of 100. For a radial kernel, the lowest cross-validation error is obtained for a gamma of 0.01 and a cost of 100.
3. (a) In code.
   (b) Support vector classifier creates 435 support vectors out of 800 training points. Out of these 216 are in level MM and the other 219 are in CH.
   (c) The training error is 17.5% and the test error rate is about 17.8%.
   (d) Optimal cost is 0.1.
   (e) Training error rate is now 16.4% and the test error rate is about 15.2%.
   (f) Radial kernel with a default gamma creates 373 support vectors which 185 are in the MM level and the other 188 are in the CH level. The classifier has a training error of 15.1% and a testing error of about 18.5%. Tuning does not reduce train and test error rates as we already used the optimal cost of 1.

(g) Polynomial kernel with default gamma creates 447 support vectors in which 225 are in the CH level and the other 222 are in the MM level. The classifier has a training error of 18.3% and a testing error of about 22.2%. Tuning reduced train and test error rates.

(h) Overall, radial basis kernel seems to be producing the least misclassification error on both train and test data.