



**Lahore University Of Management Sciences**  
**BSc (Honours) Programme**  
**MS Computer Science Programme**

Roll # \_\_\_\_\_

<b>Course Title</b>	_____ Pattern Recognition _____	<b>Quarter</b>	_____ Spring _____
<b>Course Code</b>	_____ CS533/CmpE533 _____	<b>Academic Year</b>	_____ 2005-2006 _____
<b>Instructor</b>	_____ Sohaib A. Khan _____ Midter	<b>Date</b>	_____ 17-04-2006 _____
<b>Exam</b>	_____ m _____	<b>Time Allowed</b>	_____ 75 minutes _____
		<b>Total Marks</b>	_____ 75 (25% of grade) _____

**DO NOT OPEN THIS EXAM UNTIL TOLD TO DO SO.**

**The instructions below must be followed strictly. Failure to do so can result in serious grade loss.**

- ⇒ *You may not*
  - *talk to anyone once the exam begins.*
  - *leave the examination room and then return.*
- ⇒ *Keep your eyes on your own paper.*
- ⇒ *Read all questions very carefully before answering them.*

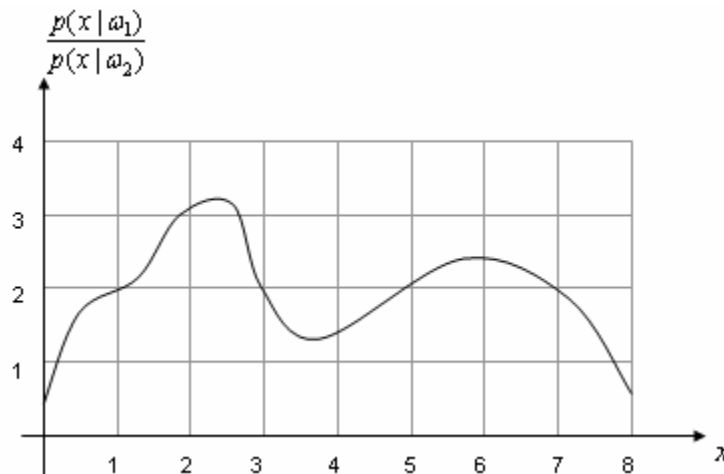
**Specific Instructions.**

1. Closed book / closed notes / no help sheet
2. Calculator usage: Calculator allowed
3. Any other instruction(s): **JUSTIFY each answer. Points will be deducted for ambiguous reasoning. If the solution of a problem is based on the solution of a previous problem that you were unable to attempt correctly, you may assume a non-trivial answer for the previous problem to get partial credit.**

1. [7 points] The heights and weights of certain set of individuals is measured and given to you in unknown units. This data is used to estimate the sample covariance matrix. Which one of the following is most likely to be the sample covariance matrix? Justify your answer.

$$\begin{bmatrix} 1.57 & 0.02 \\ 0.02 & 2.39 \end{bmatrix} \begin{bmatrix} 1.57 & 0.81 \\ 0.74 & 2.39 \end{bmatrix} \begin{bmatrix} 1.57 & -0.81 \\ -0.81 & 2.39 \end{bmatrix} \begin{bmatrix} 1.57 & 0.81 \\ 0.81 & 2.39 \end{bmatrix} \begin{bmatrix} 1.57 & 2.45 \\ 2.45 & 2.39 \end{bmatrix} \begin{bmatrix} 1.57 & 0.81 \\ 0.02 & 2.39 \end{bmatrix}$$

2. [7 points] The figure below shows the likelihood ratio for a two category problem. What are the decision regions when  $P(\omega_1) = 1/3$  and  $P(\omega_2) = 2/3$ , and a 0-1 loss function is used.



3. How are the regions going to change if the loss function is not 0-1, but instead,  $\lambda_{11} = \lambda_{22} = 0$  and  $\lambda_{21} > \lambda_{12}$

4. [7 points] If  $\Sigma_1$  is a valid covariance matrix, for what range of values of a scalar  $\alpha$  is  $\Sigma_2$  a valid covariance matrix, where  $\Sigma_2 = \alpha\Sigma_1$ ?
5. [7 points] A friend has designed a classifier for a categorizing apples and oranges. Analyzing the problem, he reports that the Bayes error is 10%, and his classifier achieves close to this error rate, and hence is almost optimal. Assuming that the Bayes error in his case is indeed 10%, is it possible for you design another classifier that gives you a better error rate than 10%? Explain.

6. [20 (8+6+6) points]  $X_1, X_2, \dots, X_n$  are independent, identically distributed according to  $\text{Geometric}(\rho)$ . Find the MLE of  $\rho$ . Compute the bias and MSE of this estimator.

7. [20 (13 + 7) points]

- a.  $X_1, X_2, \dots, X_n$  are independent, identically distributed according to  $\text{Geometric}(p)$ . Find the Bayes point estimator of  $p$  if the prior distribution of  $p$  is known to be  $\text{Beta}(\alpha, \beta)$ .
- b. Set up the integral to find the Bayes Estimate (non-point) of the density of  $x$  given iid data points  $X_1, X_2, \dots, X_n$  (You do not have to solve the integral, just show its form).