

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**  
(END SEMESTER EXAMINATION)

CLASS: BTECH  
BRANCH: AIML

SEMESTER : V  
SESSION : MO/2024

**SUBJECT: AI301 SUPERVISED LEARNING**

TIME: 3 Hours

FULL MARKS: 50

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

- |  |     | CO | BL |
|--|-----|----|----|
| Q.1(a) Considering that mean square error (MSE) is the objective function between the estimation $\hat{y}$ and target data $y$ , derive the expression for estimating the parameters $\omega_1$ and $\omega_2$ for the linear function $y = \omega_1 x + \omega_2$ | [5] | 1  | 5  |
| Q.1(b) Suppose a binary classifier produced the following confusion matrix:  | [5] | 1  | 3  |

	Predicted Positive	Predicted Negative
Actual Positive	50	10
Actual Negative	5	35

- | <ol style="list-style-type: none"> <li>i. What is the accuracy of this classifier?</li> <li>ii. Calculate the precision for the "Positive" class.</li> <li>iii. Calculate the recall for the "Positive" class.</li> <li>iv. Calculate the F1-score for the "Positive" class.</li> <li>v. Calculate the specificity for the "Negative" class.</li> </ol>  |             |             |          |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
|--|-------------|-------------|----------|-------|-------|-------|-----|------|------|----|--------|-----|------|------|-----|-------|------|--------|--------|-----|--------|------|------|--------|-----|-------|------|------|--------|----|-------|------|--------|--------|----|-------|------|------|------|-----|-------|-----|------|--------|----|--------|-----|--------|------|-----|-------|------|------|--------|----|--|--|--|
| Q.2(a) Derive the back-propagation algorithm for learning model parameters in a neural network.  | [5]         | 2           | 5        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.2(b) Discuss the following (i) Generalization and overfitting (ii) Gradient descent algorithm  | [5]         | 2           | 6        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.3(a) What is the role of Lagrange multipliers in the optimization of SVM parameters? Derive the expression for estimating the parameters for the SVM constrained optimization problem.   | [5]         | 3           | 5        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.3(b) What is the Kernel Trick? Illustrate how it facilitates that the computations are done in the original low-dimensional space.   | [5]         | 3           | 3        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.4(a) Calculate, based on information gain, which feature is chosen as the root node of the Decision Tree for classifying the following data. All intermediate computations must be shown.  | [5]         | 4           | 3        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Weather</th><th>Temperature</th><th>Humidity</th><th>Wind</th><th>Play?</th></tr> </thead> <tbody> <tr><td>Sunny</td><td>Hot</td><td>High</td><td>Weak</td><td>No</td></tr> <tr><td>Cloudy</td><td>Hot</td><td>High</td><td>Weak</td><td>Yes</td></tr> <tr><td>Sunny</td><td>Mild</td><td>Normal</td><td>Strong</td><td>Yes</td></tr> <tr><td>Cloudy</td><td>Mild</td><td>High</td><td>Strong</td><td>Yes</td></tr> <tr><td>Rainy</td><td>Mild</td><td>High</td><td>Strong</td><td>No</td></tr> <tr><td>Rainy</td><td>Cool</td><td>Normal</td><td>Strong</td><td>No</td></tr> <tr><td>Rainy</td><td>Mild</td><td>High</td><td>Weak</td><td>Yes</td></tr> <tr><td>Sunny</td><td>Hot</td><td>High</td><td>Strong</td><td>No</td></tr> <tr><td>Cloudy</td><td>Hot</td><td>Normal</td><td>Weak</td><td>Yes</td></tr> <tr><td>Rainy</td><td>Mild</td><td>High</td><td>Strong</td><td>No</td></tr> </tbody> </table> | Weather     | Temperature | Humidity | Wind  | Play? | Sunny | Hot | High | Weak | No | Cloudy | Hot | High | Weak | Yes | Sunny | Mild | Normal | Strong | Yes | Cloudy | Mild | High | Strong | Yes | Rainy | Mild | High | Strong | No | Rainy | Cool | Normal | Strong | No | Rainy | Mild | High | Weak | Yes | Sunny | Hot | High | Strong | No | Cloudy | Hot | Normal | Weak | Yes | Rainy | Mild | High | Strong | No |  |  |  |
| Weather  | Temperature | Humidity    | Wind     | Play? |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Sunny  | Hot         | High        | Weak     | No    |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Cloudy   | Hot         | High        | Weak     | Yes   |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Sunny  | Mild        | Normal      | Strong   | Yes   |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Cloudy   | Mild        | High        | Strong   | Yes   |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Rainy  | Mild        | High        | Strong   | No    |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Rainy  | Cool        | Normal      | Strong   | No    |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Rainy  | Mild        | High        | Weak     | Yes   |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Sunny  | Hot         | High        | Strong   | No    |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Cloudy   | Hot         | Normal      | Weak     | Yes   |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Rainy  | Mild        | High        | Strong   | No    |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.4(b) Discuss different sources of overfitting/underfitting in decision trees. Suggest resolution strategies.   | [5]         | 4           | 6        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.5(a) Describe the boosting algorithm for ensemble learning.  | [5]         | 5           | 2        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |
| Q.5(b) Explain the working of Random forests. How do they break the correlation in predictions?  | [5]         | 5           | 2        |       |       |       |     |      |      |    |        |     |      |      |     |       |      |        |        |     |        |      |      |        |     |       |      |      |        |    |       |      |        |        |    |       |      |      |      |     |       |     |      |        |    |        |     |        |      |     |       |      |      |        |    |  |  |  |