WEEK 3: CORE MATHEMATICS FOR MACHINE LEARNING

DAY 12 (08/07/2025)

Calculus for Machine Learning:

Calculus is a crucial part of machine learning because it helps models **learn and improve**. Essentially, ML models are mathematical functions, and calculus tells the model how to adjust itself to make better predictions. Without calculus, a model wouldn't know which direction to move or how much to change weights to reduce errors.

1. Derivatives

- A derivative measures **how a function changes when its input changes**.
- In simple words, it tells us the slope of the function at a particular point.
- **Why it matters in ML:** Derivatives help us understand how sensitive our predictions are to changes in model parameters (weights).

Example:

- Suppose we are predicting student marks based on hours studied.
- If the weight for "hours studied" changes slightly, the predicted marks change.
- The **derivative tells us exactly how much the prediction will change**.

2. Partial Derivatives

- Many ML models have **multiple weights** or variables.

- A partial derivative tells us **how the function changes with respect to one variable** while keeping the others constant.

Example:

- Partial derivative with respect to hours studied: tells us how changing **only hours studied** affects the prediction error, while **attendance remains fixed**.

- Partial derivative with respect to attendance: tells us the effect of **only attendance**.

3. Gradient

- A **gradient** is a vector containing all partial derivatives of a function.

- It points in the **direction of the steepest increase**.

- In ML, we use the gradient to **know which direction to adjust all weights** to reduce error.

- **Key idea:** We move **opposite the gradient** to minimize the loss function — this is the foundation of **gradient descent**.

Example:

In a neural network predicting student marks:

➔ The gradient tells us **how much to adjust each weight** (hours studied, attendance, etc.) to reduce the prediction error.

➔ The model updates all weights slightly in the opposite direction of the gradient to improve predictions.

4. Why Gradient and Derivatives Matter in ML

- **Helps the model learn efficiently:** Without gradients, models wouldn't know how to update weights.

- **Prevents overshooting:** Proper use of derivatives ensures models move smoothly towards the best solution.

- **Foundation for optimization:** Gradient descent and its variants rely entirely on derivatives to minimize loss functions in regression, classification, and neural networks.

Reflection

Today I learned that calculus acts like a guide for ML models. By calculating derivatives and gradients:

- The model knows **how sensitive predictions are** to each feature.

- It knows **how to adjust each weight** in a multi-feature system.

- Step by step, the model moves towards **better accuracy and lower error**.