

Last Name	First Name	Student ID Number
«Last_Name»	«First_Name»	«UTA_ID»

Prob #	1	2	3	4	Total
Points	21	29	25	25	

Time: 80 Minutes

Seat Number:

76

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$$F(\mathbf{x}) = F(\mathbf{x}^*) + \nabla F(\mathbf{x})^T \Big|_{\mathbf{x} = \mathbf{x}^*} (\mathbf{x} - \mathbf{x}^*) + \frac{1}{2} (\mathbf{x} - \mathbf{x}^*)^T \nabla^2 F(\mathbf{x}) \Big|_{\mathbf{x} = \mathbf{x}^*} (\mathbf{x} - \mathbf{x}^*) + \dots$$

$$\frac{\mathbf{p}^T \nabla F(\mathbf{x})}{\|\mathbf{p}\|} \quad \frac{\mathbf{p}^T \nabla^2 F(\mathbf{x}) \mathbf{p}}{\|\mathbf{p}\|^2} \quad \alpha_k = -\frac{\mathbf{g}_k^T \mathbf{p}_k}{\mathbf{p}_k^T \mathbf{A} \mathbf{p}_k}$$

$$\mathbf{x}_{k+1} = \mathbf{x}_k - \alpha_k \mathbf{g}_k \quad \mathbf{x}_{k+1} = \mathbf{x}_k + \alpha_k \mathbf{p}_k$$

$$L_i = \sum_{j \neq i} \max(0, y_j - y_i + \Delta)$$

$$S(y_i) = \frac{e^{y_i}}{\sum_j e^{y_j}}$$

$$H(p,q)=-\sum_x p(x)log(q(x))$$

$$L_i = -\log(\frac{e^{y_i}}{\sum_j e^{y_j}})$$

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1. Consider a convolutional neural network.

Note: **Do NOT consider Biases.**

Input layer:

Input to this CNN are color images of size **100x70x3** with the **batch size = 30**

Note: Input image has **different horizontal and vertical** resolution.

Next layer is Conv2D layer:

Number of filters: **15**, filter size: **9x9**; stride: **3x3**; padding: **4x4**

Q1: What is the shape of the weight matrix for this layer? **Q1:** _____

Q2: What is the shape of the output (tensor) of this layer? **Q2:** _____

Next layer is Conv2D layer:

Number of filters: **10**, filter size: **4x4**; stride: **2x2**; padding: **1x1**

Q3: What is the shape of the weight matrix for this layer? **Q3:** _____

Q4: What is the shape of the output (tensor) of this layer? **Q4:** _____

Next layer is Flatten layer:

Q5: What is the shape of the output (tensor) for this layer? **Q5:** _____

Next layer is Dense layer:

Number of nodes: **50**

Q6: What is the shape of the weight matrix for this layer? **Q6:** _____

Q7: What is the shape of the output (tensor) for this layer? **Q7:** _____

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Problem 1 Continued

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2. Consider the expression:

$$f(x, y) = \frac{xy}{35 - \min(xy, x^2)}$$

given the inputs: $x = 5$, $y = 6$

Draw the computational graph and calculate the $\frac{\delta f(x,y)}{\delta x}$ and $\frac{\delta f(x,y)}{\delta y}$

For proper credit, you **MUST SHOW** all the numerical values **for each node** as they flow in the forward and backward path in the computational graph.

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Problem 2 Continued

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3. Using tensorflow, complete the following function to create and train a **two-layer** neural network. The **first layer** has **7 sigmoid** nodes. The **output layer** has **linear nodes**. Loss function should be **MSE**. Anything not specified in the description should be **inferred from the function's parameters and not hardcoded**.

Code should include initializing weights, training loop with forward pass, gradient calculation, and weight updates.

You may assume the entire dataset is one batch.

DO NOT USE Keras

```
import numpy as np
```

```
import tensorflow as tf
```

```
def create_and_train_nn(X, Y, epochs, alpha):
```

|| || ||

```
:param X: Array of input [n_samples,input_dimensions]
```

```
:param y: Array of desired outputs [n_samples , target_dimension].
```

```
:param epochs: number of epochs
```

```
:param alpha: Learning rate:
```

```
:return w1, w2 Weight matrices."""
```

[illegible]

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4. Complete the code for the following function.

USE numpy only. DO NOT USE tensorflow or keras

```
import numpy as np
def calculate_svm (yhat,yt):
# This function calculates the SVM error for the entire data set
# yhat: Array of actual outputs [num_of_samples,num_of_classes]
# yt: Array of desired outputs [num_of_samples]
# Each element of yt array is the index of the true class.
# return: SVM for the entire data set (A single float number).
# Return value is the average of all the SVMs for the samples.
# Assume delta is equal to 1
```

[illegible]

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Problem 4 Continued

[illegible]