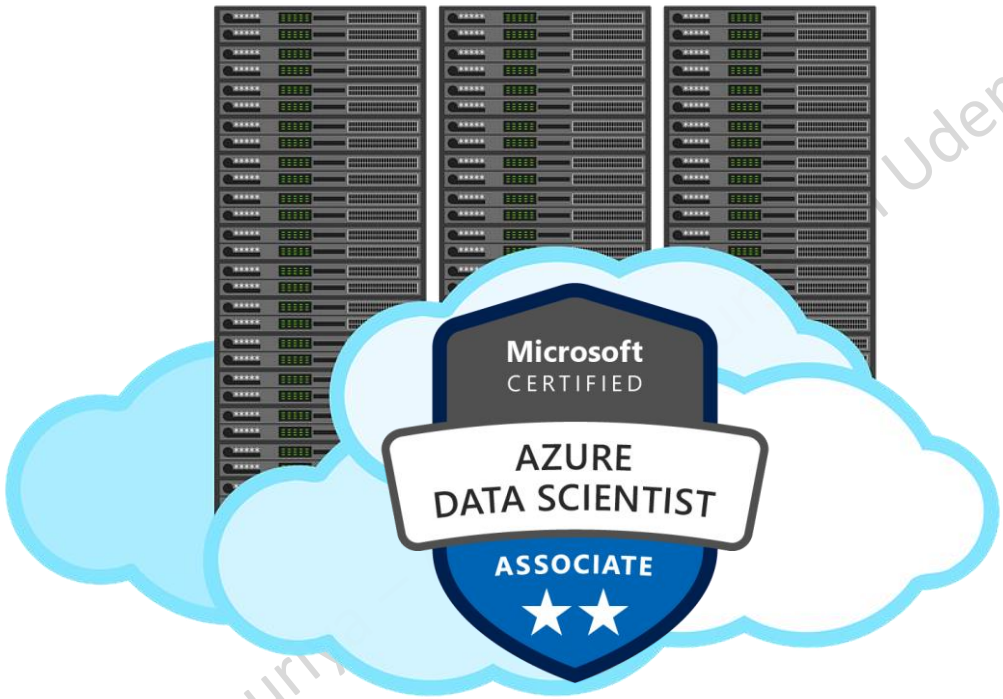
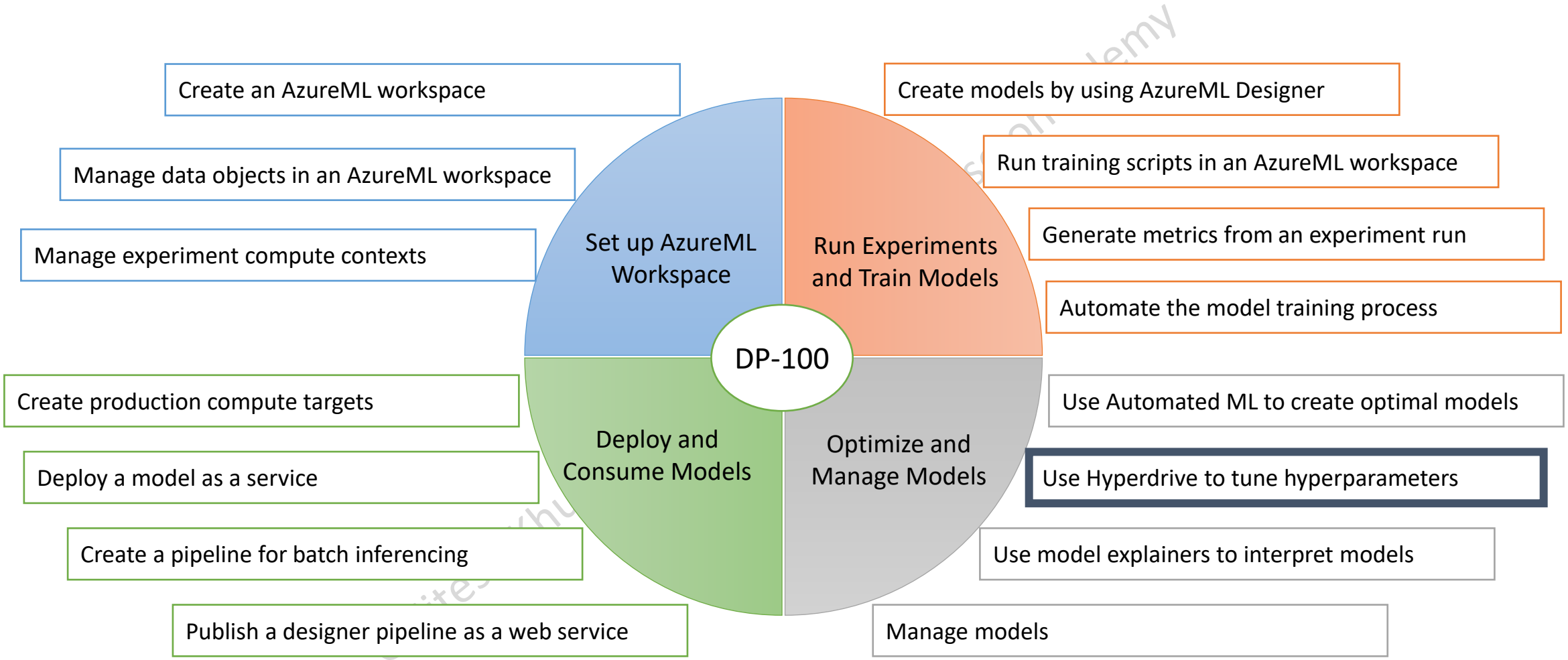
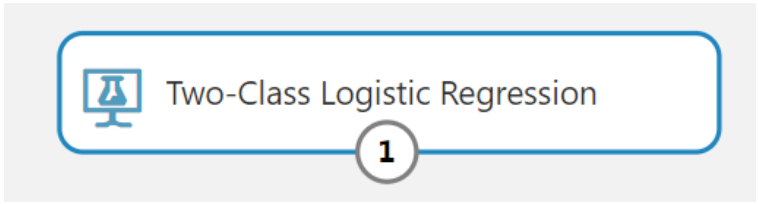
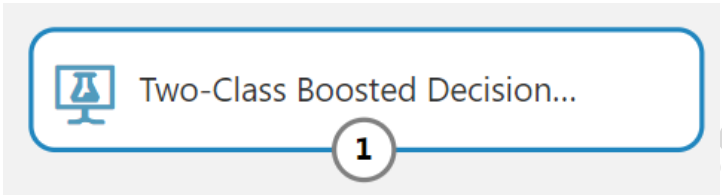


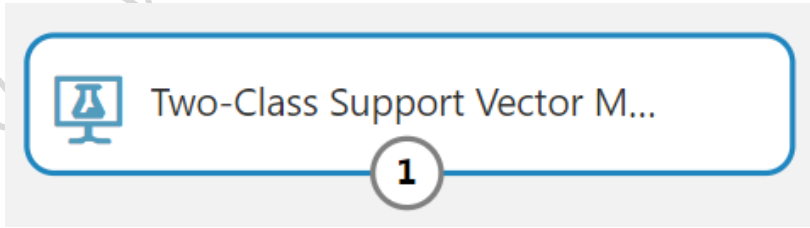
Azure Machine Learning



Models and Parameters



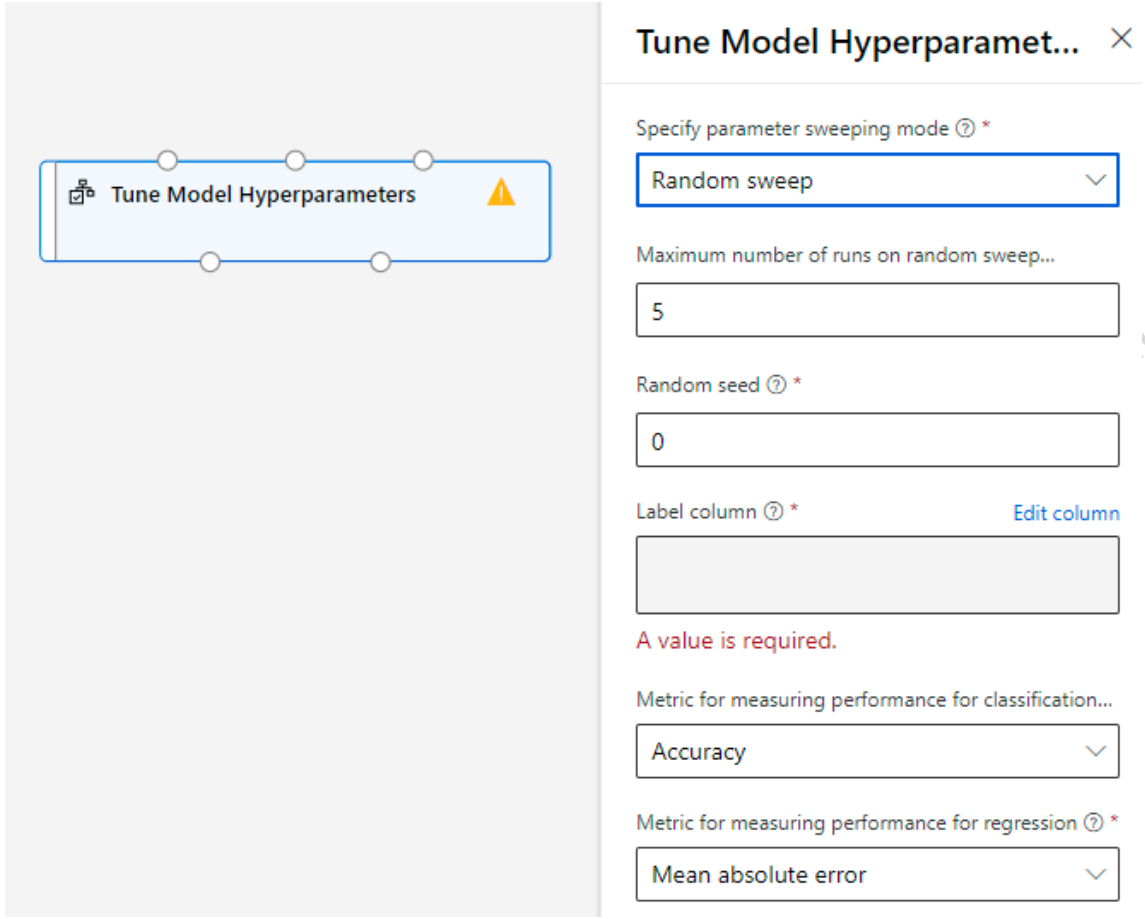




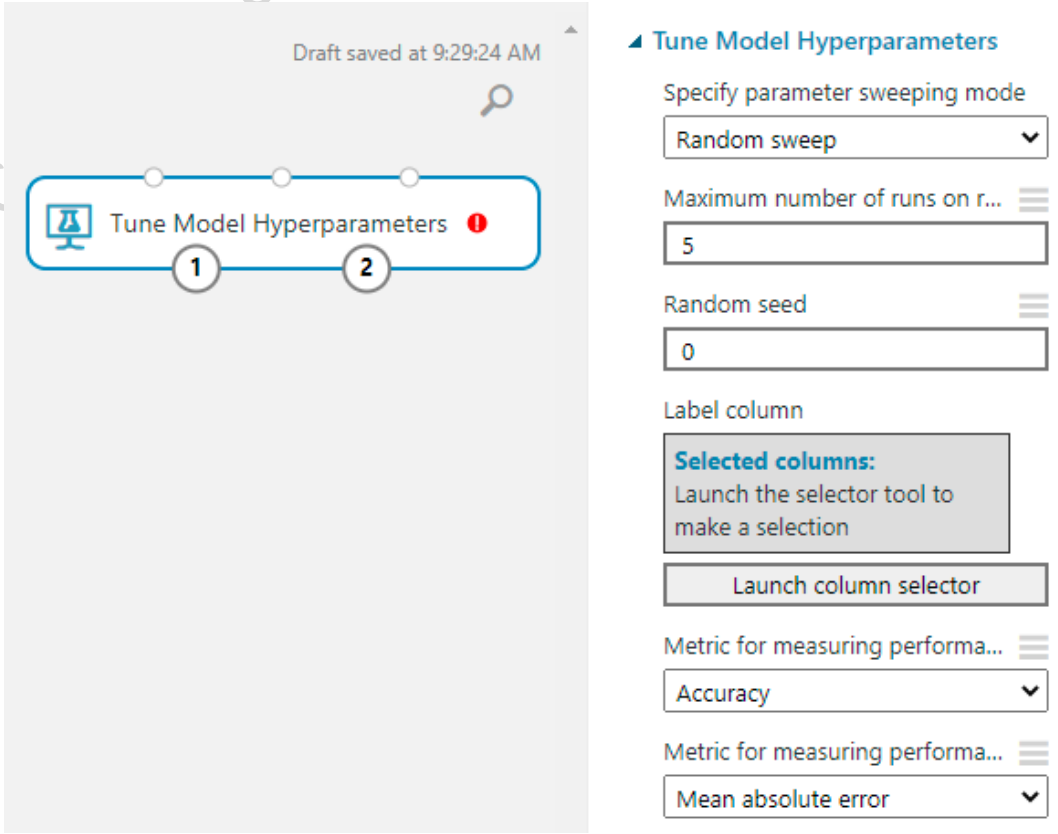
Tune Model Hyperparameters

- Helps in determining the best possible combination of hyperparameters
- Also known as hyperparameter optimization
- Performance metric to measure
  - Accuracy
  - Precision
  - Recall
  - AUC
  - F1Score

Designer



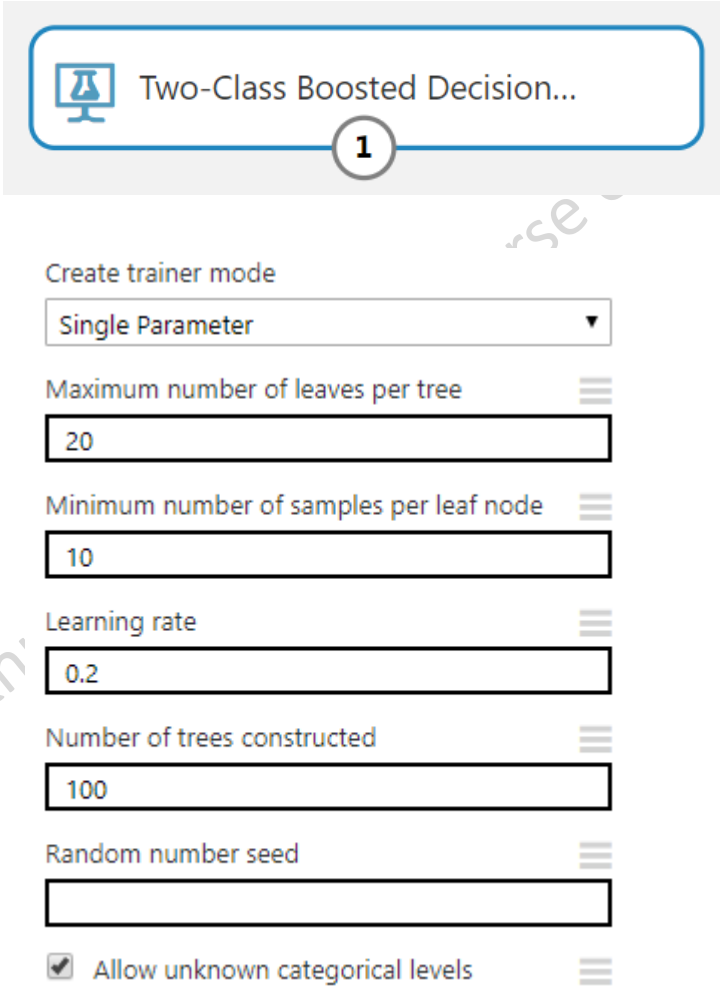
Classic Studio



Parameter Search Space

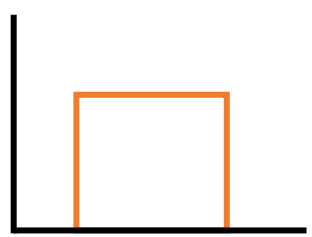
Discrete

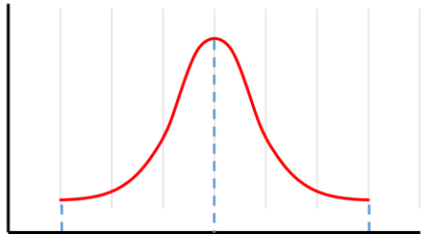
- Discrete with finite set of values
- [4, 5, 8, 15, 20]



Continuous

- Specified as a distribution over a continuous range
- Uniform (low, high)
- Log-Uniform (low, high)
- Normal (mu, stddev)
- Log-Normal (mu, stddev)





Select a Sampling Method

- Random Sampling
- Grid Sampling
- Bayesian Sampling

What is a Grid?

- Cartesian Product of Parameters
- Parameter 1 → 1, 2, 3
- Parameter 2 → A, B, C, D

Parameter 1 →

← Parameter 2

	1	2	3
A	A, 1	A, 2	A, 3
B	B, 1	B, 2	B, 3
C	C, 1	C, 2	C, 3
D	D, 1	D, 2	D, 3

Random Sampling

Parameter 1 →

← Parameter 2

	1	2	3
A	A, 1	A, 2	A, 3
B	B, 1	B, 2	B, 3
C	C, 1	C, 2	C, 3
D	D, 1	D, 2	D, 3

Grid Sampling

Parameter 1 →

← Parameter 2

	1	2	3
A	A, 1	A, 2	A, 3
B	B, 1	B, 2	B, 3
C	C, 1	C, 2	C, 3
D	D, 1	D, 2	D, 3

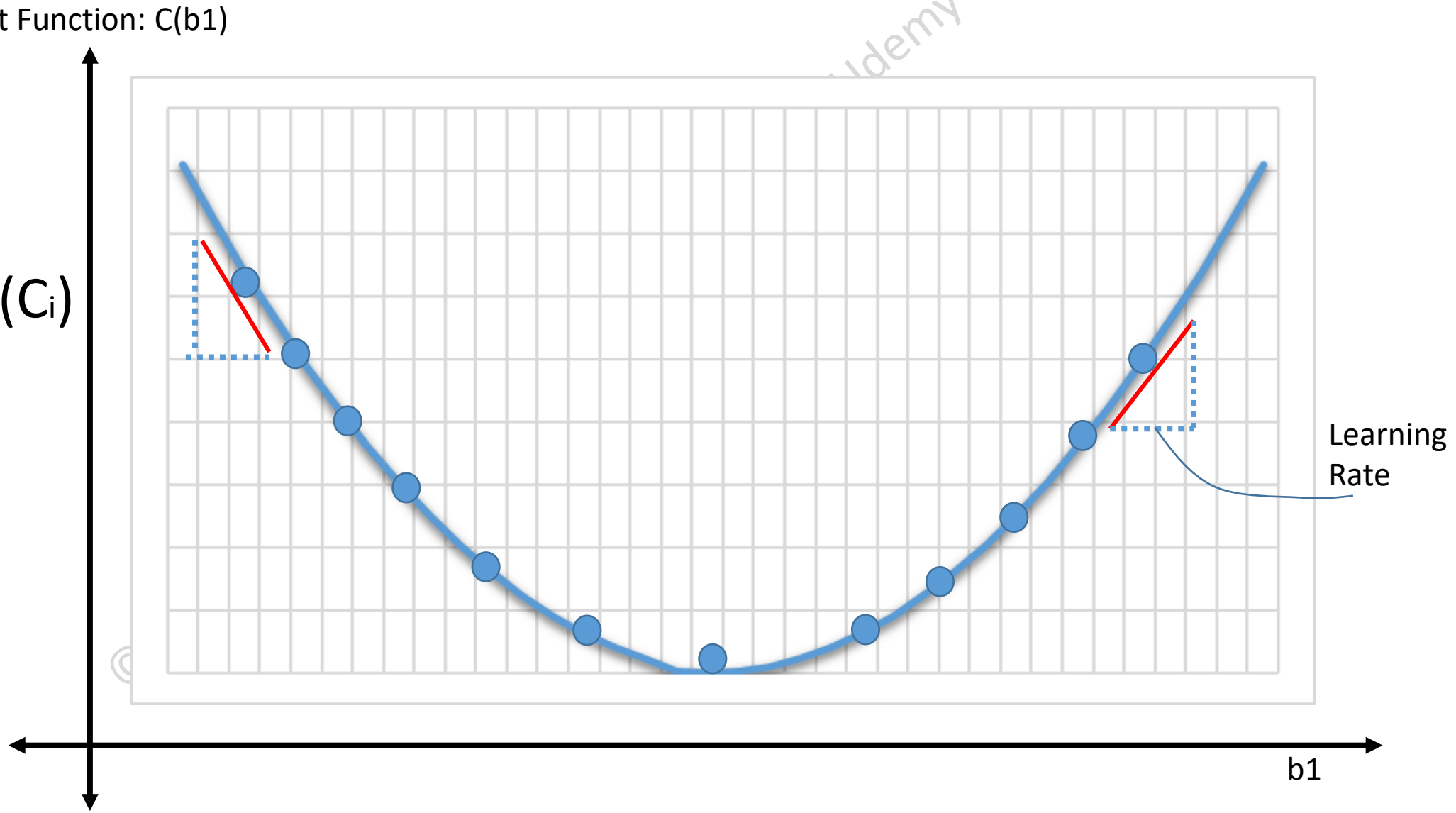
Sampling Method Comparison

Random Sampling	Grid Sampling	Bayesian Sampling
• Supports Discrete as well as Continuous Hyperparameters	• Supports only Discrete Hyperparameters	• Support Discrete as well as Continuous Hyperparameters
• Selects the combination with best results	• Selects the combination with best results	• Selects the combination by learning from the previous run
		• Uses Bayesian Optimization for getting the best combination.
• Supports early termination	• Supports early termination	• Does not support early termination

What is Early Termination Policy?

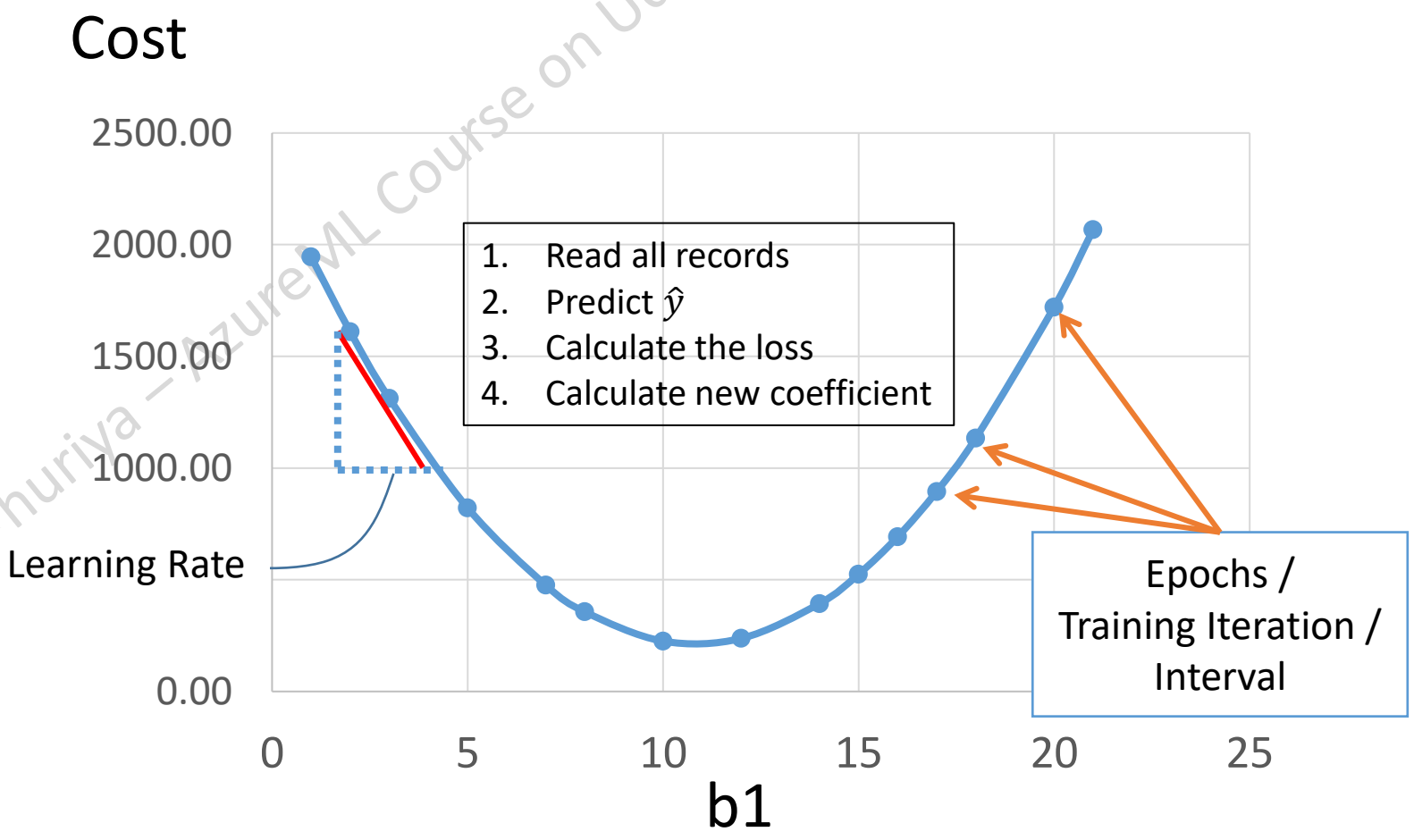
Gradient Descent

$$b_j := b_j - \alpha f(C_i)$$



Cost Function Plot

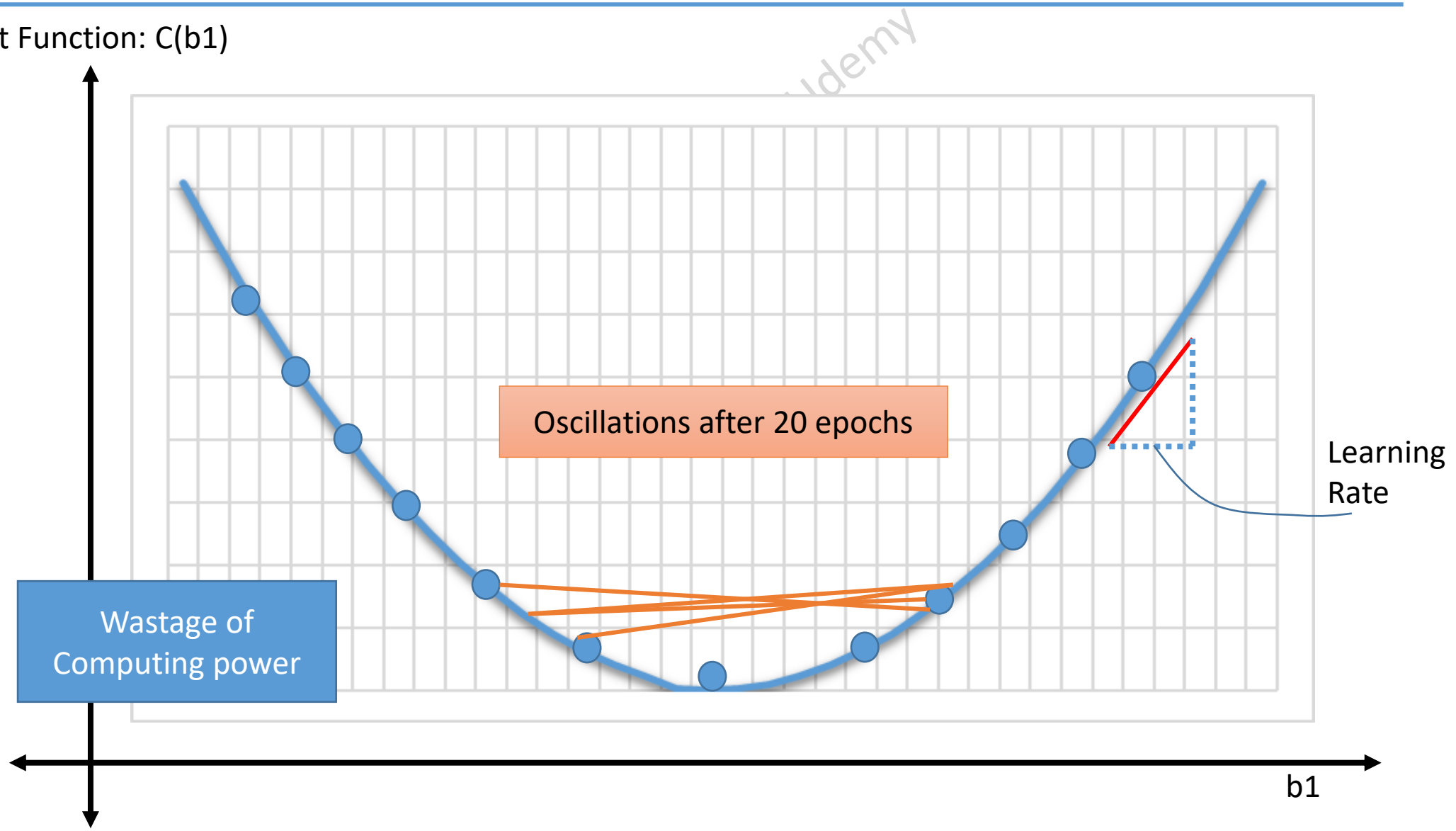
b0	b1	cost
0	1	1944.54
0	2	1610.08
0	3	1311.46
0	5	821.77
0	7	475.46
0	8	356.08
0	10	224.85
0	12	237.00
0	14	392.54
0	15	524.08
0	16	691.46
0	17	894.69
0	18	1133.77
0	20	1719.46
0	21	2066.08



Gradient Descent

Hyperparameter

1. Learning Rate
   - 0.01
   - 0.05
   - 0.1
   - **0.2**
2. No of epochs
   - 20
   - **50**
   - **100**
   - **200**
   - **1000**



Gradient Descent

Hyperparameter

1. Learning Rate
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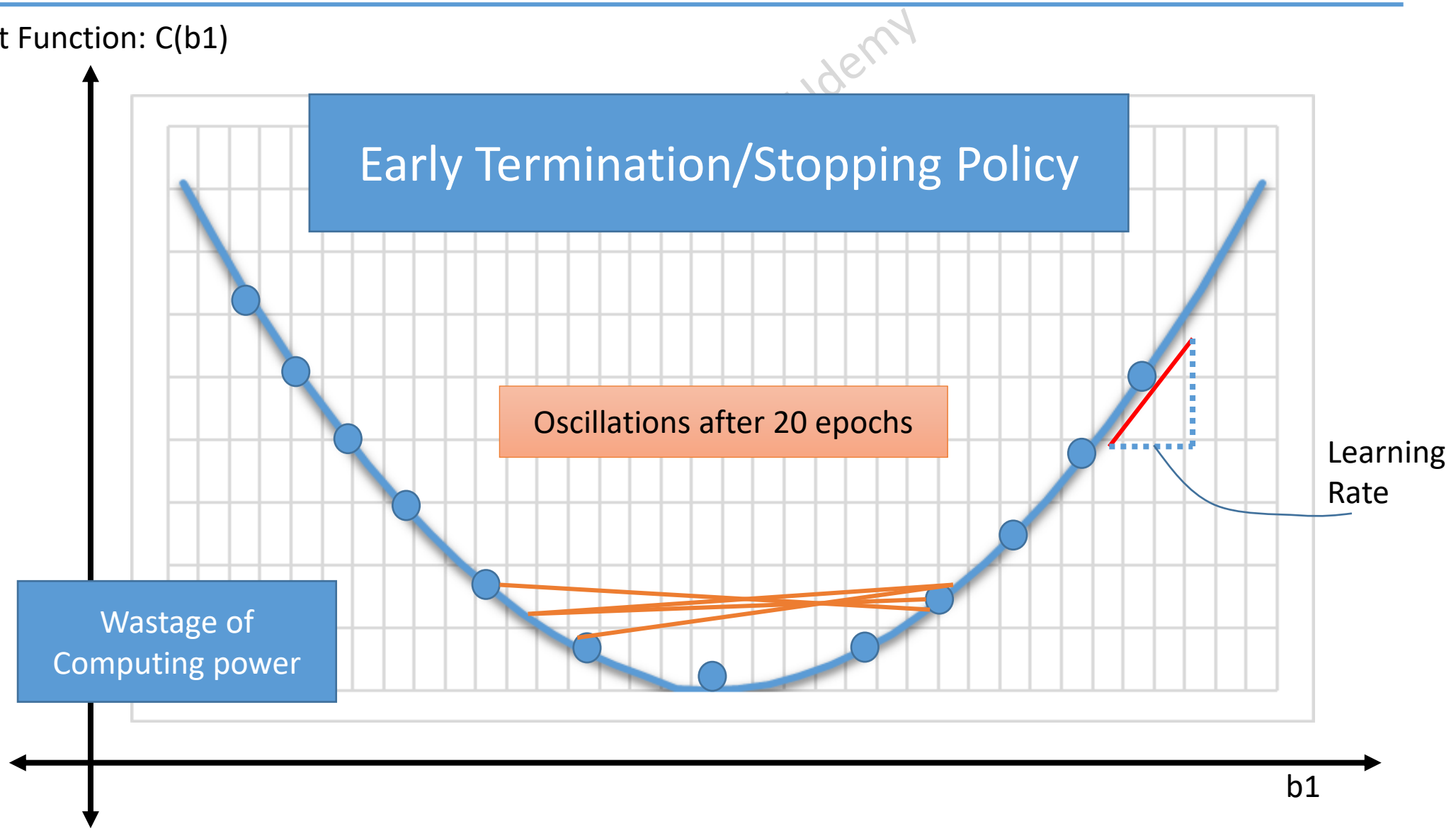


Types of Early Termination Policies in Hyperdrive

- Bandit Policy
- Median Stopping Policy
- Truncation Selection Policy
- No Termination Policy

Bandit Policy – Slack Amount

```
from azureml.train.hyperdrive import BanditPolicy

early_termination_policy = BanditPolicy(slack_amount = 0.1,
                                        evaluation_interval=1,
                                        delay_evaluation=10)
```

- Slack Factor
- Slack Amount
- Evaluation interval
- Delay Evaluation

- Apply the policy after delay_evaluation of 10 epochs.
- After the delay of 10, apply the policy on every epoch.
- Check if the primary metric of the new epoch is less than,
  (PM of Best Epoch – 0.1) then terminate/stop the Run

e.g.

During the first 10 epochs, if epoch 5 provides the best accuracy of 0.90, then if any epoch after 10th one, reports accuracy less than (0.90 – 0.10 = 0.80), the run will be terminated/stopped.

Bandit Policy – Slack Factor

```
from azureml.train.hyperdrive import BanditPolicy

early_termination_policy = BanditPolicy(slack_factor = 0.1,
                                        evaluation_interval=1,
                                        delay_evaluation=10)
```

- Slack Factor
- Slack Amount
- Evaluation interval
- Delay Evaluation

- Apply the policy after delay_evaluation of 10 epochs.
- After the delay of 10, apply the policy on every epoch.
- Check if the best primary metric is greater than,
  (Current PM + Current PM* 0.1) then terminate/stop the Run

e.g.

During the first 10 epochs, if epoch 5 provides the best accuracy of 0.90. Then if the epoch 11th reports an accuracy of 0.8, it will compare (0.8 + 0.8*0.1 = 0.88). As 0.9 is greater than 0.88, the run will be terminated/stopped.

Median Stopping Policy

```
from azureml.train.hyperdrive import MedianStoppingPolicy

early_termination_policy = MedianStoppingPolicy(evaluation_interval=1, delay_evaluation=5)
```

Epoch	Accuracy	Running average
1	0.85	0.850
2	0.86	0.855
3	0.87	**0.860**
4	0.87	0.862
5	0.88	0.866
6	**??**	

Median of all previous Running Averages

Truncation Selection Policy

```
from azureml.train.hyperdrive import TruncationSelectionPolicy

early_termination_policy = TruncationSelectionPolicy(evaluation_interval=1,
                                                     truncation_percentage=20,
                                                     delay_evaluation=10)
```

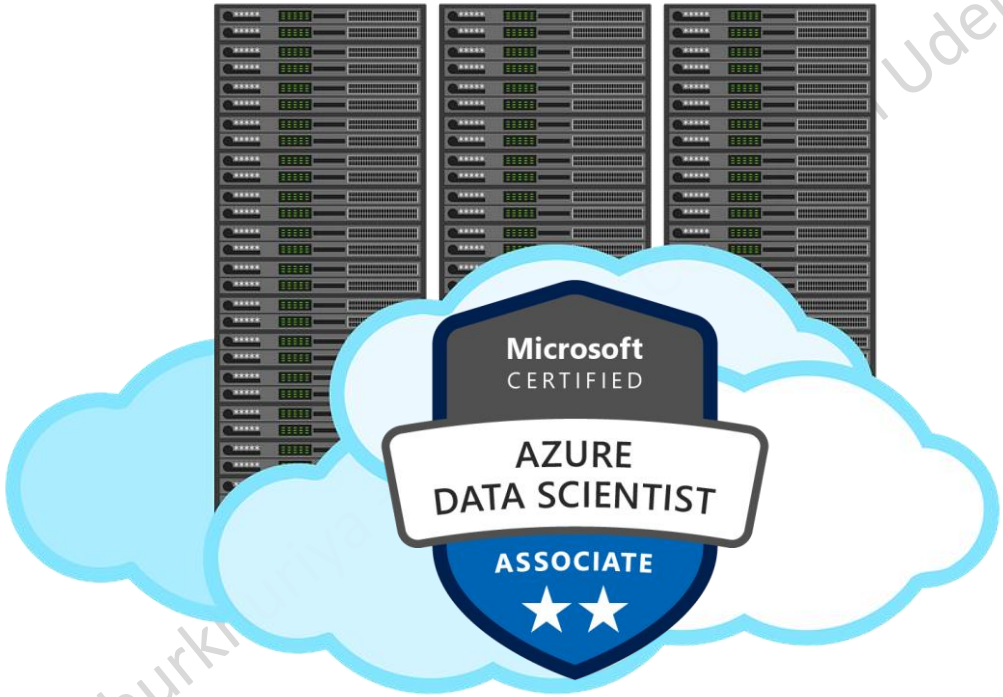
Epoch	Accuracy
1	**0.85**
2	0.86
3	0.87
4	0.87
5	0.88
6	0.86
7	0.87
8	0.86
9	**0.85**
10	0.86

- Expunge the bottom 20% of the iterations
- Does not stop or terminate the Run.

When to apply Early Termination?

- Algorithms with learning rate and epochs
    - SGDClassifier
    - SGDRegresser
    - XGBoost
    - Deep learning

Azure Machine Learning



Thank You..!!