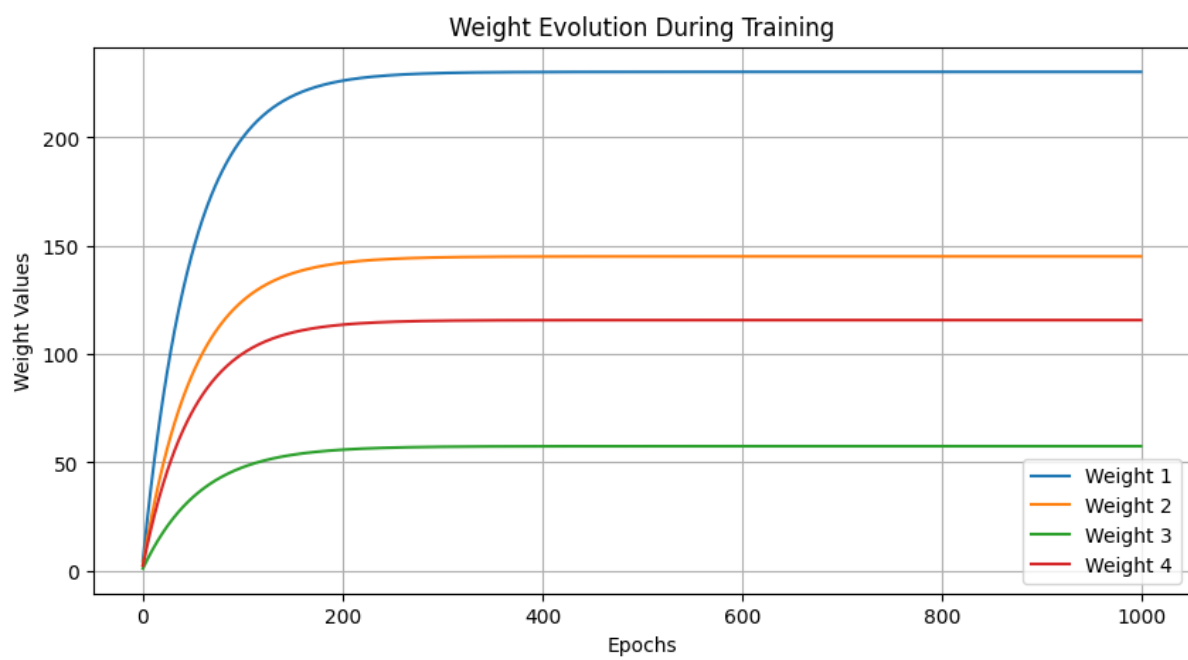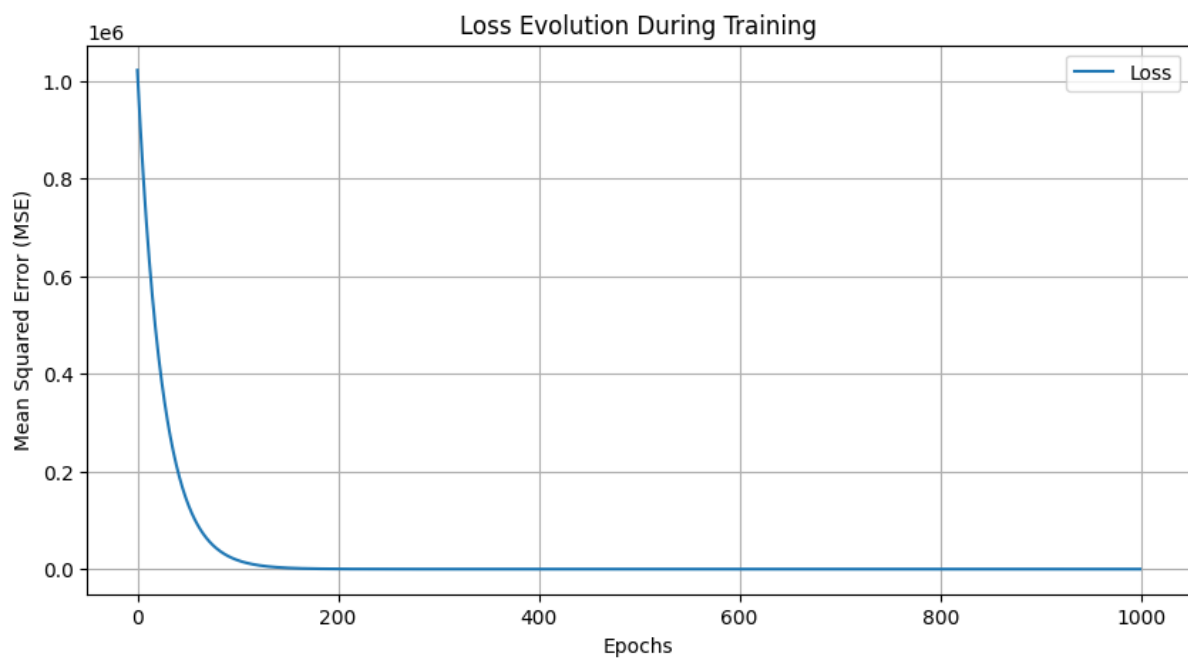Name: Gururaj Bidnur
Roll no. : ME23MTECH12001
Assignment: 2
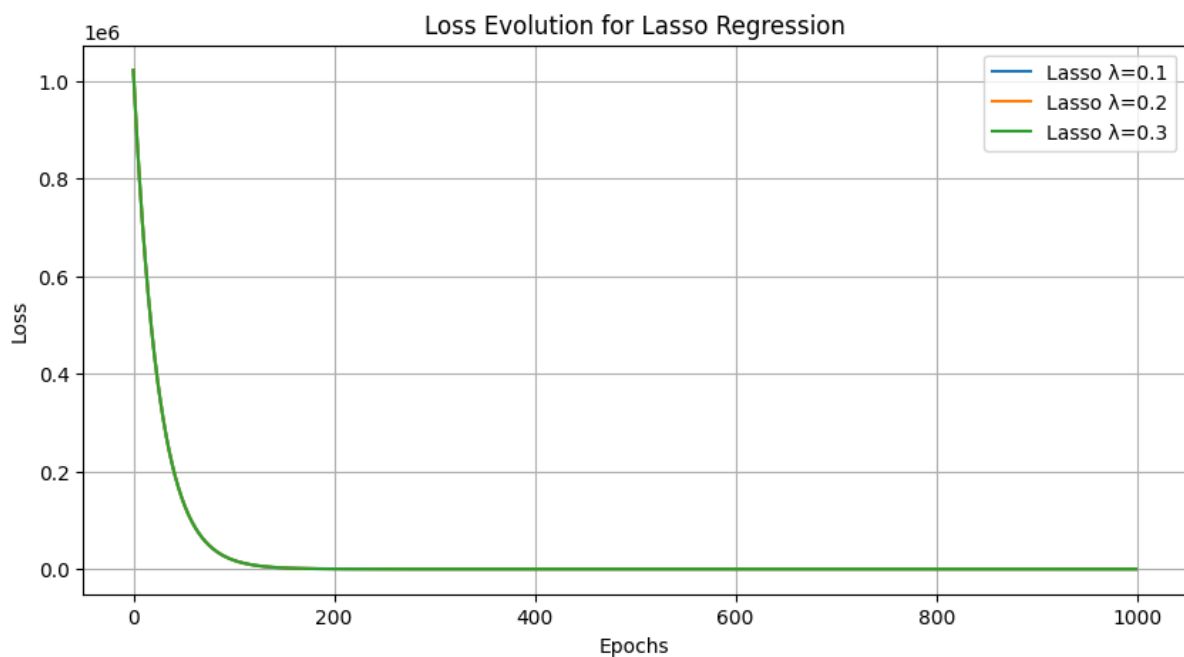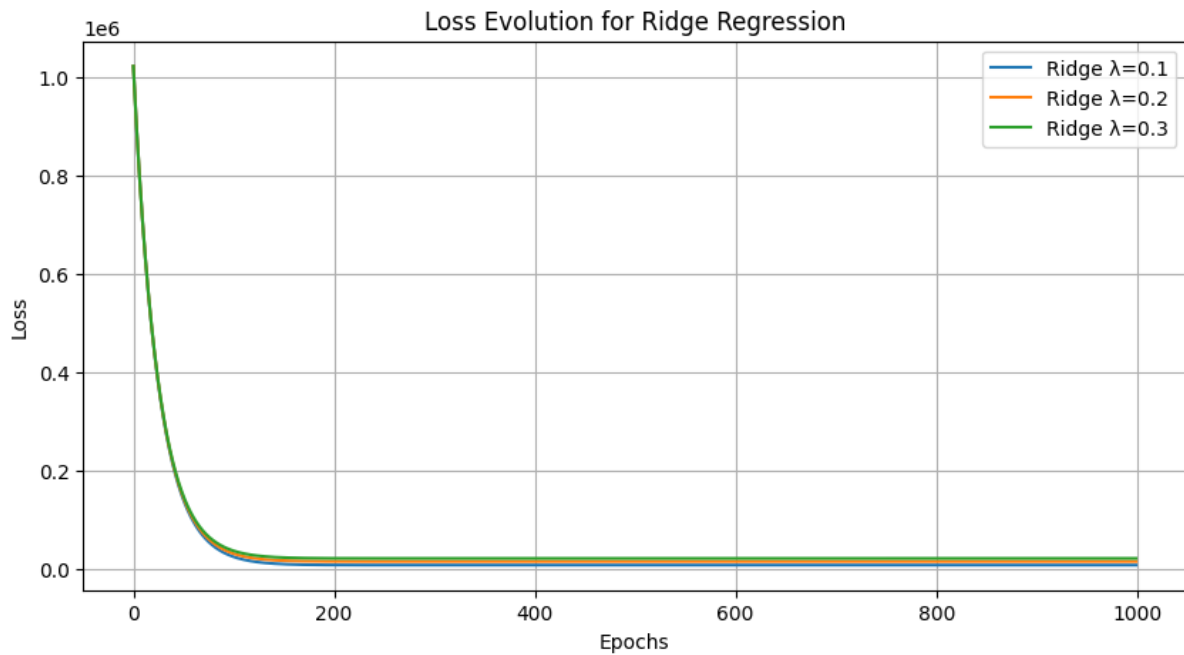
Question1:
Output-

1 a.)

Test MSE: 3.6157483819677507e-12
Test R-squared: 1.0

1 b.)

Loss Evolution for Ridge Regression

Loss Evolution for Lasso Regression

Ridge Regression Results:
λ=0.1: MSE=210.707221, R^2=0.997643
λ=0.2: MSE=766.525816, R^2=0.991424
λ=0.3: MSE=1575.314208, R^2=0.982375

Lasso Regression Results:
λ=0.1: MSE=0.010554, R^2=1.000000
λ=0.2: MSE=0.042217, R^2=1.000000
λ=0.3: MSE=0.094988, R^2=0.999999

1.c)

Epoch 0: Loss = 1021969.3557881222
Epoch 100: Loss = 993041.4547069963
Epoch 200: Loss = 973519.5649184054
Epoch 300: Loss = 960343.6679610902
Epoch 400: Loss = 951449.7784247018
Epoch 500: Loss = 945445.5628350175
Epoch 600: Loss = 941391.6573790944
Epoch 700: Loss = 938654.2242348307
Epoch 800: Loss = 936805.5271391463
Epoch 900: Loss = 935556.8789724573
Model Comparison:
OLS: MSE=934720.317477, R^2=1.000000
Ridge (λ=0.1): MSE=210.707000, R^2=0.997600
Ridge (λ=0.2): MSE=766.526000, R^2=0.991400
Ridge (λ=0.3): MSE=1575.314000, R^2=0.982400
Lasso (λ=0.1): MSE=0.010550, R^2=1.000000
Lasso (λ=0.2): MSE=0.042220, R^2=1.000000
Lasso (λ=0.3): MSE=0.094990, R^2=0.999990
OLS Loss History (First 10 values): [1021969.3557881222, 1021620.1499058027,
1021272.3150598501, 1020925.8458630823, 1020580.7369495021,
1020236.9829742134, 1019894.5786133388, 1019553.5185639355,
1019213.7975439148, 1018875.4102919586]

Loss Evolution During Training

Weight Evolution for OLS
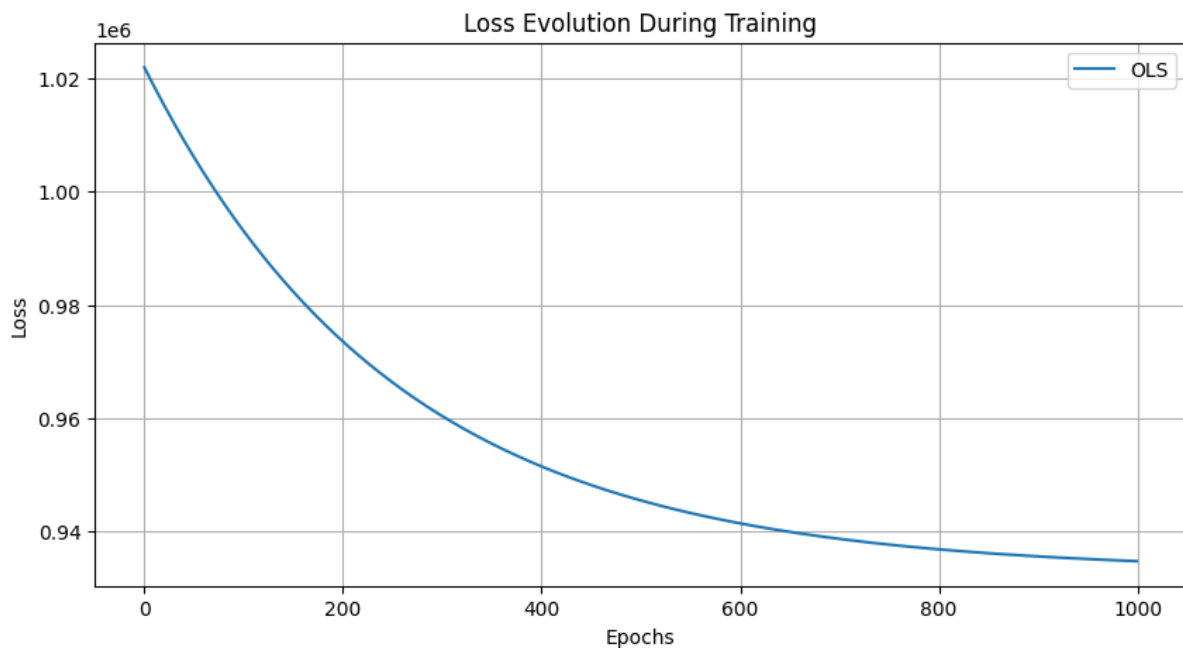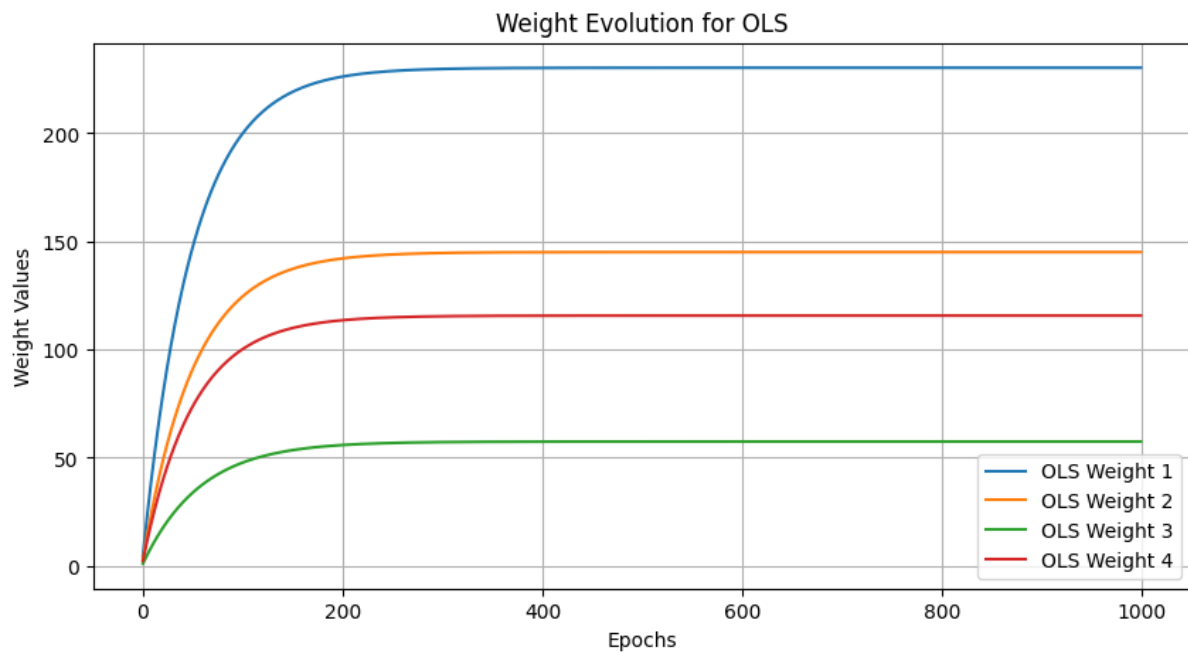
Final Weights:
OLS Weights: [198.79229866 123.85858983 47.43291644 99.62934914]
Ridge Weights: {0.1: 'N/A', 0.2: 'N/A', 0.3: 'N/A'}
Lasso Weights: {0.1: 'N/A', 0.2: 'N/A', 0.3: 'N/A'}

Question 2:
Output-

2 a.)

Training with SGD optimizer:
Epoch 0: Loss = 0.383591
Epoch 100: Loss = 0.106921
Epoch 200: Loss = 0.018698
Epoch 300: Loss = 0.002732
Epoch 400: Loss = 0.000386
Epoch 500: Loss = 0.000055
Epoch 600: Loss = 0.000008
Epoch 700: Loss = 0.000001
Epoch 800: Loss = 0.000000
Epoch 900: Loss = 0.000000

Training with BatchGD optimizer:
Epoch 0: Loss = 0.383591
Epoch 100: Loss = 0.106921
Epoch 200: Loss = 0.018698
Epoch 300: Loss = 0.002732
Epoch 400: Loss = 0.000386
Epoch 500: Loss = 0.000055

```
Epoch 600: Loss = 0.000008
Epoch 700: Loss = 0.000001
Epoch 800: Loss = 0.000000
Epoch 900: Loss = 0.000000

Training with Momentum optimizer:
Epoch 0: Loss = 0.383591
Epoch 100: Loss = 0.000002
Epoch 200: Loss = 0.000000
Epoch 300: Loss = 0.000000
Epoch 400: Loss = 0.000000
Epoch 500: Loss = 0.000000
Epoch 600: Loss = 0.000000
Epoch 700: Loss = 0.000000
Epoch 800: Loss = 0.000000
Epoch 900: Loss = 0.000000

Training with Adam optimizer:
Epoch 0: Loss = 0.383591
Epoch 100: Loss = 0.000874
Epoch 200: Loss = 0.000000
Epoch 300: Loss = 0.000000
Epoch 400: Loss = 0.000000
Epoch 500: Loss = 0.000000
Epoch 600: Loss = 0.000000
Epoch 700: Loss = 0.000000
Epoch 800: Loss = 0.000000
Epoch 900: Loss = 0.000000
```

Loss Evolution for Different Optimizers
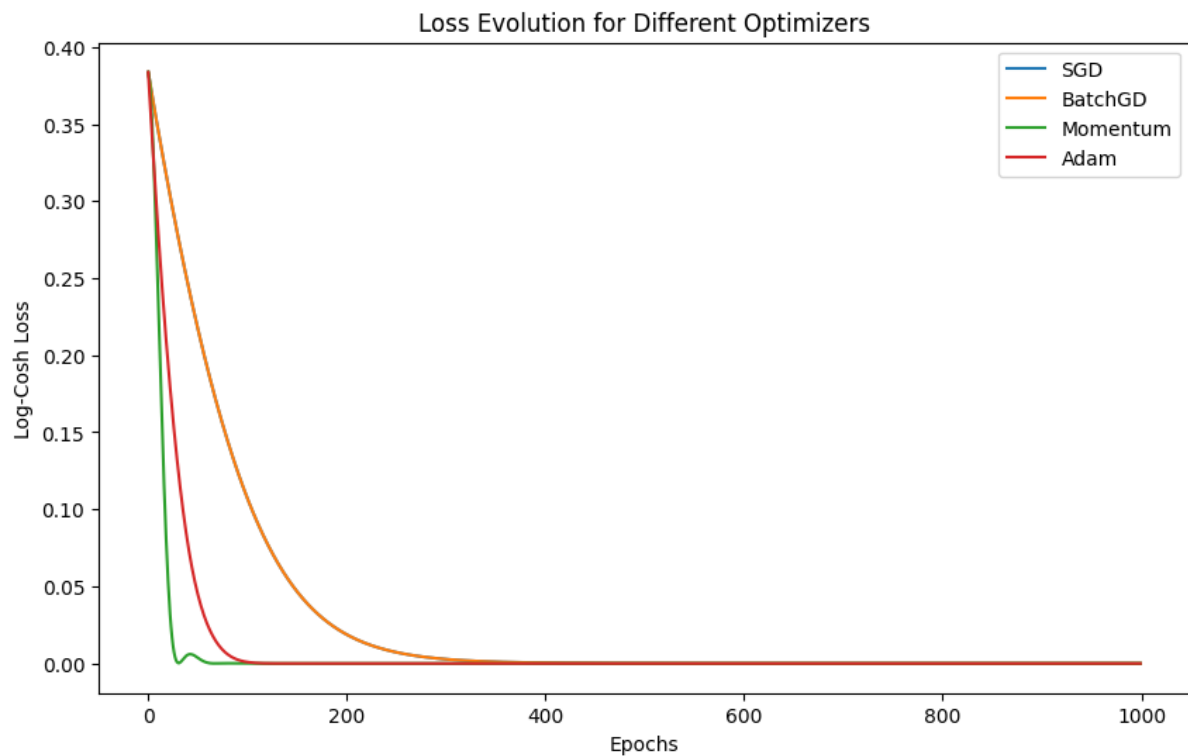
Final Weights for SGD: [0.77170732 0.48616571 0.192543   0.38767369]

Final Weights for BatchGD: [0.77170732 0.48616571 0.192543   0.38767369]

Final Weights for Momentum: [0.77175779 0.48621147 0.19257473 0.38770315]

Final Weights for Adam: [0.77175779 0.48621147 0.19257473 0.38770315]

2 b.)

SGD - Epoch 0: Loss = 0.382940
SGD - Epoch 100: Loss = 0.345337
SGD - Epoch 200: Loss = 0.309816
SGD - Epoch 300: Loss = 0.276460
SGD - Epoch 400: Loss = 0.245338
SGD - Epoch 500: Loss = 0.216499
SGD - Epoch 600: Loss = 0.189971
SGD - Epoch 700: Loss = 0.165751
SGD - Epoch 800: Loss = 0.143814
SGD - Epoch 900: Loss = 0.124102
BatchGD - Epoch 0: Loss = 0.382940
BatchGD - Epoch 100: Loss = 0.345337
BatchGD - Epoch 200: Loss = 0.309816
BatchGD - Epoch 300: Loss = 0.276460
BatchGD - Epoch 400: Loss = 0.245338

BatchGD - Epoch 500: Loss = 0.216499
BatchGD - Epoch 600: Loss = 0.189971
BatchGD - Epoch 700: Loss = 0.165751
BatchGD - Epoch 800: Loss = 0.143814
BatchGD - Epoch 900: Loss = 0.124102
Momentum - Epoch 0: Loss = 0.382940
Momentum - Epoch 100: Loss = 0.114936
Momentum - Epoch 200: Loss = 0.017567
Momentum - Epoch 300: Loss = 0.002080
Momentum - Epoch 400: Loss = 0.000236
Momentum - Epoch 500: Loss = 0.000027
Momentum - Epoch 600: Loss = 0.000003
Momentum - Epoch 700: Loss = 0.000000
Momentum - Epoch 800: Loss = 0.000000
Momentum - Epoch 900: Loss = 0.000000
Adam - Epoch 0: Loss = 0.382225
Adam - Epoch 100: Loss = 0.280602
Adam - Epoch 200: Loss = 0.197798
Adam - Epoch 300: Loss = 0.133347
Adam - Epoch 400: Loss = 0.086005
Adam - Epoch 500: Loss = 0.053380
Adam - Epoch 600: Loss = 0.032019
Adam - Epoch 700: Loss = 0.018536
Adam - Epoch 800: Loss = 0.010302
Adam - Epoch 900: Loss = 0.005464

Weight Evolution During Training
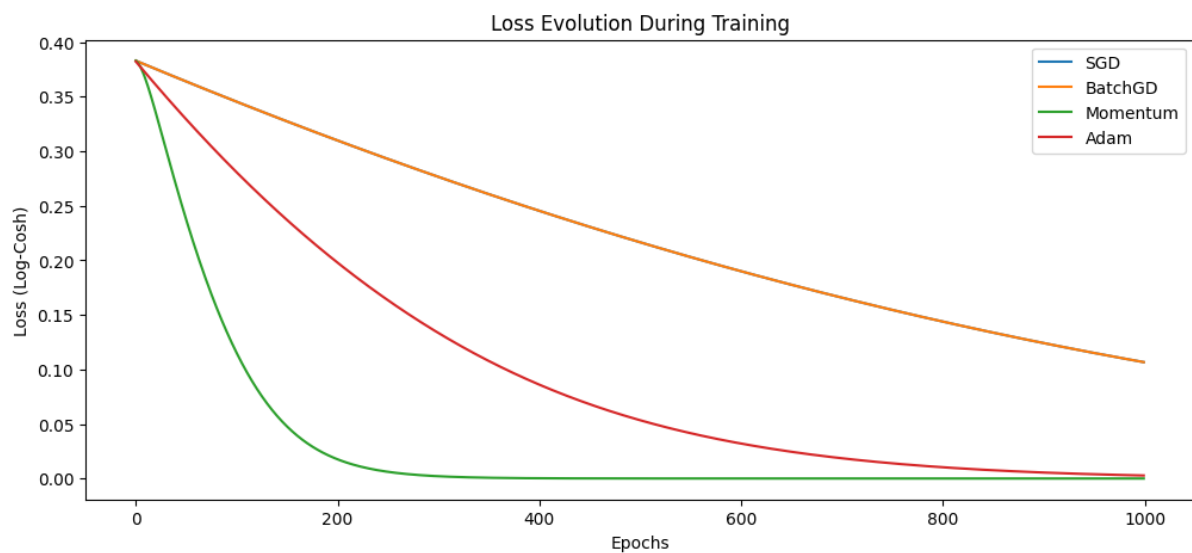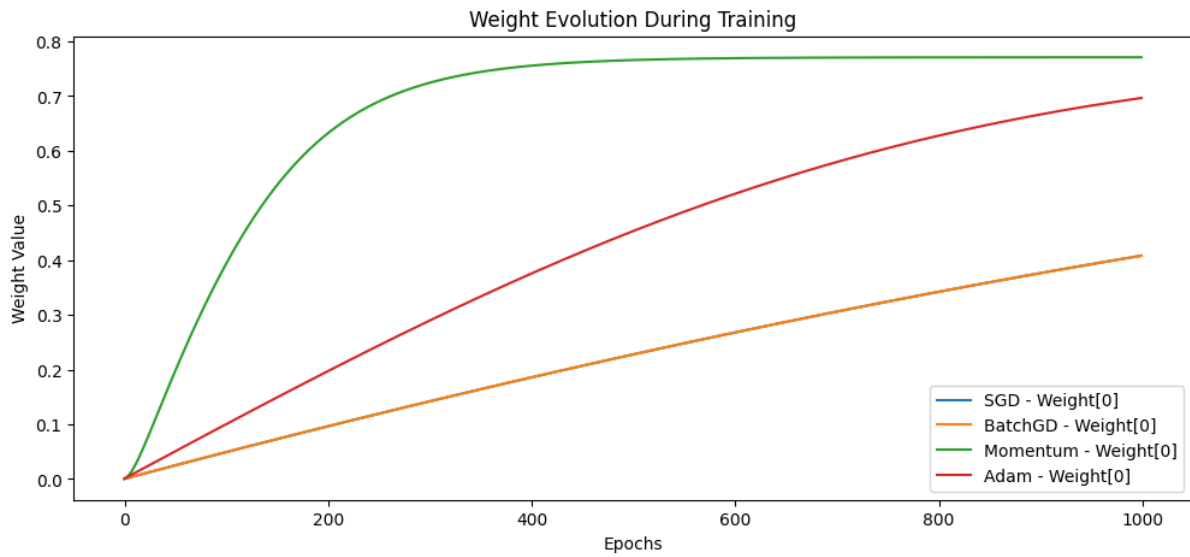
SGD Final Weights: [0.40825613 0.24373394 0.08794201 0.19716678]
BatchGD Final Weights: [0.40825613 0.24373394 0.08794201 0.19716678]
Momentum Final Weights: [0.77085022 0.4845631 0.19212967 0.38725144]
Adam Final Weights: [0.69647546 0.48090181 0.19125065 0.38748369]

Model Comparison:
SGD: MSE=0.233422, R^2=0.767330
BatchGD: MSE=0.233422, R^2=0.767330
Momentum: MSE=0.000000, R^2=1.000000
Adam: MSE=0.005521, R^2=0.994496