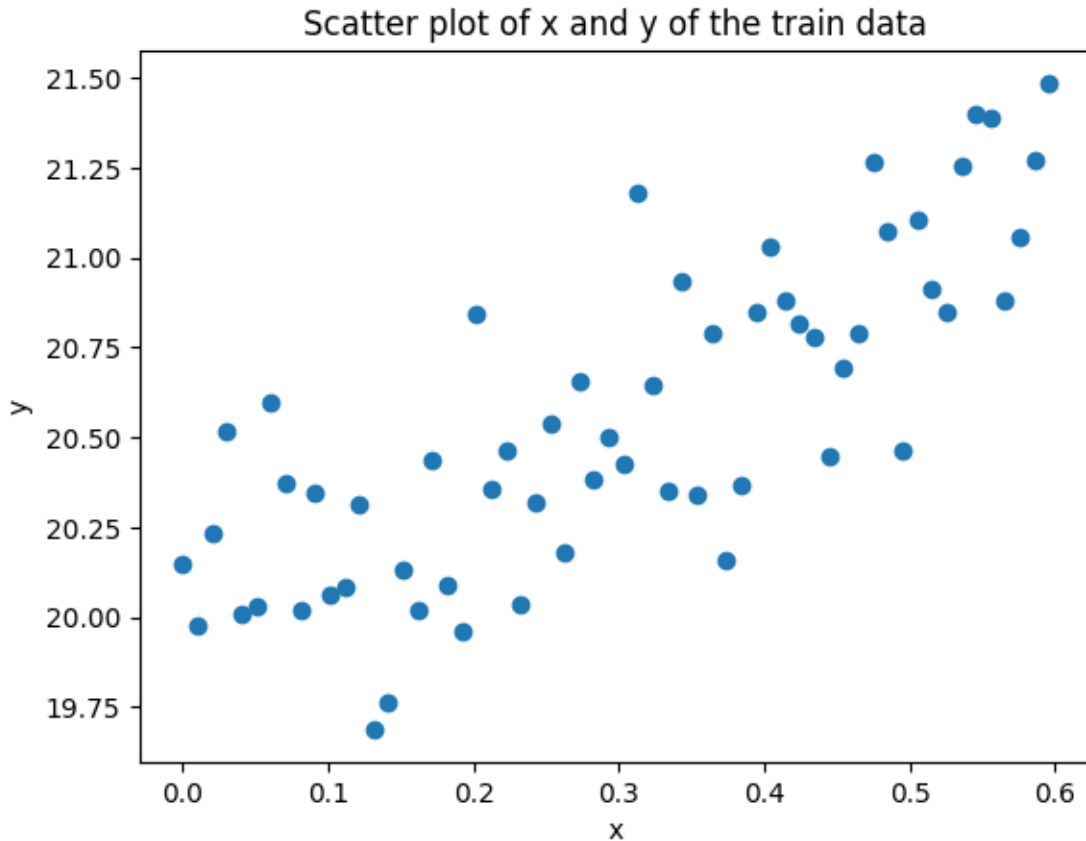# lab1

March 18, 2024

```
[2]: import numpy as np
     import matplotlib.pyplot as plt
```

```
[3]: # a.                  lab1_train.csv.

     train_data = np.genfromtxt("lab_1_train.csv", delimiter=",", skip_header=1)
     x_train = train_data[:, 1]
     y_train = train_data[:, 2]

     plt.scatter(x_train, y_train)
     plt.title('Scatter plot of x and y of the train data')
     plt.xlabel('x')
     plt.ylabel('y')
     plt.show()
```

Scatter plot of x and y of the train data


```
[4]: def mean_squared_error(actual_values, predicted_values):
         if len(actual_values) != len(predicted_values):
             raise ValueError("Input lists must have the same length.")

         squared_errors = [(actual - predicted) ** 2 for actual, predicted in␣
      ↪zip(actual_values, predicted_values)]
         mse = sum(squared_errors) / len(actual_values)

         return mse

     def linear_regression(x, m, b):
         return m * x + b

     def compute_gradients(x, y, m, b):
         y_pred = linear_regression(x, m, b)
         dm = (1/len(x)) * np.sum((y_pred - y) * x)
         db = (1/len(x)) * np.sum(y_pred - y)
         return dm, db

     m = 0
```

```python
b = 0
learning_rate = 0.01
convergence_threshold = 1e-3
iterations = 1000
prev_mse = float('inf')

for epoch in range(iterations):
    dm, db = compute_gradients(x_train, y_train, m, b)
    m = m - learning_rate * dm
    b = b - learning_rate * db

    # b.                                        .          Mean Squared Error  ⌴
  ↵           .
    mse = mean_squared_error(linear_regression(x_train, m, b), y_train)
    print(f"Epoch {epoch + 1}/{iterations}, MSE: {mse}, Weights: {m, b}")
    if abs(prev_mse - mse) < convergence_threshold:
        print("Converged.")
        break

    prev_mse = mse
```

Epoch 1/1000, MSE: 413.31715515958723, Weights: (0.06183906732682434, 0.20549563191038453)
Epoch 2/1000, MSE: 404.3557535251843, Weights: (0.12299196792752087, 0.40875203957377215)
Epoch 3/1000, MSE: 395.5888804625636, Weights: (0.18346619347012755, 0.6097936598708571)
Epoch 4/1000, MSE: 387.0123131555248, Weights: (0.243269153861219, 0.8086446629898695)
Epoch 5/1000, MSE: 378.62192045660646, Weights: (0.3024081781382132, 1.0053289553371325)
Epoch 6/1000, MSE: 370.41366089714313, Weights: (0.3608905153519401, 1.199870182415855)
Epoch 7/1000, MSE: 362.3835807405215, Weights: (0.4187233354395782, 1.392291731673507)
Epoch 8/1000, MSE: 354.52781207769675, Weights: (0.47591373008806426, 1.5826167353181193)
Epoch 9/1000, MSE: 346.8425709640502, Weights: (0.5324687135880805, 1.770868073103848)
Epoch 10/1000, MSE: 339.3241555966928, Weights: (0.5883952236787213, 1.9570683750861386)
Epoch 11/1000, MSE: 331.96894453133575, Weights: (0.643700122382942, 2.1412400243468213)
Epoch 12/1000, MSE: 324.7733949378687, Weights: (0.6983901968338898, 2.323405159689465)
Epoch 13/1000, MSE: 317.7340408938062, Weights: (0.7524721600922162, 2.5035856783053183)

Epoch 14/1000, MSE: 310.84749171477927, Weights: (0.8059526519544703, 2.6818032384101524)
Epoch 15/1000, MSE: 304.11043032127026, Weights: (0.8588382397526695, 2.8580792618523287)
Epoch 16/1000, MSE: 297.5196116407997, Weights: (0.9111354191451433, 3.0324349366924017)
Epoch 17/1000, MSE: 291.07186104480223, Weights: (0.9628506148987473, 3.204891219754571)
Epoch 18/1000, MSE: 284.76407281943085, Weights: (1.01399018166254, 3.375468839150287)
Epoch 19/1000, MSE: 278.59320866955983, Weights: (1.064560404733016, 3.544188296774316)
Epoch 20/1000, MSE: 272.55629625526103, Weights: (1.114567500810987, 3.711069870773561)
Epoch 21/1000, MSE: 266.65042776005146, Weights: (1.1640176187502047, 3.8761336179889447)
Epoch 22/1000, MSE: 260.8727584902202, Weights: (1.2129168402978117, 4.039399376370639)
Epoch 23/1000, MSE: 255.2205055045612, Weights: (1.2612711808267116, 4.200886767366935)
Epoch 24/1000, MSE: 249.6909462738535, Weights: (1.3090865900599478, 4.360615198287046)
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Epoch 149/1000, MSE: 16.51281071681804, Weights: (4.485079174719119,
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Epoch 352/1000, MSE: 0.6199945637891066, Weights: (5.286660765249589, 18.513673454394002)
Epoch 353/1000, MSE: 0.6157483100881741, Weights: (5.287020945188364, 18.518279170692278)
Epoch 354/1000, MSE: 0.611589957346437, Weights: (5.2873669709949, 18.52283775656412)
Epoch 355/1000, MSE: 0.6075175998109831, Weights: (5.28769900000733, 18.52734972549024)
Epoch 356/1000, MSE: 0.6035293730975585, Weights: (5.288017187845868, 18.53181558534772)
Epoch 357/1000, MSE: 0.5996234532925527, Weights: (5.288321688431558, 18.536235838471146)
Epoch 358/1000, MSE: 0.5957980560744668, Weights: (5.288612654004818, 18.540610981713108)
Epoch 359/1000, MSE: 0.5920514358544402, Weights: (5.288890235143783, 18.544941506504024)
Epoch 360/1000, MSE: 0.5883818849354513, Weights: (5.289154580782443, 18.549227898911315)
Epoch 361/1000, MSE: 0.5847877326897684, Weights: (5.289405838228593, 18.55347063969793)
Epoch 362/1000, MSE: 0.5812673447542348, Weights: (5.289644153181572, 18.55767020438025)
Epoch 363/1000, MSE: 0.5778191222430592, Weights: (5.2898696697498275, 18.56182706328533)
Epoch 364/1000, MSE: 0.5744415009776599, Weights: (5.290082530468268, 18.565941681607548)
Epoch 365/1000, MSE: 0.5711329507332525, Weights: (5.290282876315443, 18.570014519464603)
Epoch 366/1000, MSE: 0.56789197450178, Weights: (5.290470846730526, 18.574046031952935)
Epoch 367/1000, MSE: 0.5647171077708408, Weights: (5.290646579630113, 18.578036669202522)
Epoch 368/1000, MSE: 0.5616069178182834, Weights: (5.290810211424846, 18.581986876431074)
Epoch 369/1000, MSE: 0.5585600030221008, Weights: (5.29096187703584, 18.585897093997648)
Epoch 370/1000, MSE: 0.5555749921853098, Weights: (5.291101709910944, 18.589767757455675)
Epoch 371/1000, MSE: 0.5526505438754887, Weights: (5.291229842040819, 18.593599297605405)
Epoch 372/1000, MSE: 0.5497853457786501, Weights: (5.291346403974842, 18.597392140545775)
Epoch 373/1000, MSE: 0.5469781140671394, Weights: (5.291451524836834, 18.601146707725725)

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Epoch 374/1000, MSE: 0.5442275927812513, Weights: (5.29154533234062,
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Epoch 375/1000, MSE: 0.5415325532242827, Weights: (5.291627952805416,
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Epoch 376/1000, MSE: 0.5388917933706983, Weights: (5.29169951117105,
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Epoch 377/1000, MSE: 0.5363041372871641, Weights: (5.291760131013014,
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Epoch 378/1000, MSE: 0.5337684345661354, Weights: (5.2918099345573575,
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Epoch 379/1000, MSE: 0.5312835597717476, Weights: (5.2918490426954135,
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Epoch 380/1000, MSE: 0.5288484118977235, Weights: (5.291877574998364,
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Epoch 381/1000, MSE: 0.5264619138370699, Weights: (5.291895649731649,
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Epoch 382/1000, MSE: 0.5241230118632662, Weights: (5.291903383869218,
18.633282704823817)
Epoch 383/1000, MSE: 0.521830675122723, Weights: (5.29190089310762,
18.636676706673423)
Epoch 384/1000, MSE: 0.5195838951382604, Weights: (5.291888291879952,
18.6400367759265)
Epoch 385/1000, MSE: 0.5173816853233616, Weights: (5.291865693369643,
18.64336328203616)
Epoch 386/1000, MSE: 0.515223080506971, Weights: (5.291833209524093,
18.646656590423717)
Epoch 387/1000, MSE: 0.5131071364686107, Weights: (5.291790951068163,
18.649917062522697)
Epoch 388/1000, MSE: 0.5110329294835837, Weights: (5.29173902751752,
18.65314505582235)
Epoch 389/1000, MSE: 0.5089995558780571, Weights: (5.29167754719183,
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Epoch 390/1000, MSE: 0.5070061315937997, Weights: (5.291606617227813,
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Epoch 391/1000, MSE: 0.5050517917623594, Weights: (5.291526343592152,
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Epoch 392/1000, MSE: 0.503135690288504, Weights: (5.291436831094266,
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Epoch 393/1000, MSE: 0.5012569994426871, Weights: (5.291338183398935,
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Epoch 394/1000, MSE: 0.49941490946236844, Weights: (5.291230503038793,
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Epoch 395/1000, MSE: 0.49760862816198903, Weights: (5.29111389142669,
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Epoch 396/1000, MSE: 0.4958373805514095, Weights: (5.290988448867905,
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Epoch 397/1000, MSE: 0.49410040846263564, Weights: (5.290854274572239,
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```

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Epoch 398/1000, MSE: 0.4923969701846412, Weights: (5.290711466665968,
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Epoch 399/1000, MSE: 0.4907263401061251, Weights: (5.2905601222036704,
18.686607802019317)
Epoch 400/1000, MSE: 0.48908780836601556, Weights: (5.290400337179922,
18.689472555545365)
Epoch 401/1000, MSE: 0.48748068051156945, Weights: (5.290232206540865,
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Epoch 402/1000, MSE: 0.4859042771638877, Weights: (5.290055824195649,
18.695117854955285)
Epoch 403/1000, MSE: 0.484357933690698, Weights: (5.289871283027752,
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Epoch 404/1000, MSE: 0.4828409998862259, Weights: (5.2896786749061695,
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Epoch 405/1000, MSE: 0.4813528396580343, Weights: (5.28947809069649,
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Epoch 406/1000, MSE: 0.47989283072065214, Weights: (5.2892696202718446,
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Epoch 407/1000, MSE: 0.47846036429585, Weights: (5.289053352523738,
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Epoch 408/1000, MSE: 0.4770548448194299, Weights: (5.288829375372764,
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Epoch 409/1000, MSE: 0.4756756896543727, Weights: (5.2885977757791975,
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Epoch 410/1000, MSE: 0.47432232881021985, Weights: (5.28835863975348,
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Epoch 411/1000, MSE: 0.4729942046685382, Weights: (5.288112052366583,
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Epoch 412/1000, MSE: 0.47169077171435486, Weights: (5.287858097760261,
18.721737564740227)
Epoch 413/1000, MSE: 0.47041149627341183, Weights: (5.287596859157194,
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Epoch 414/1000, MSE: 0.4691558562551343, Weights: (5.287328418871018,
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Epoch 415/1000, MSE: 0.4679233409011646, Weights: (5.287052858316247,
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Epoch 416/1000, MSE: 0.4667134505393735, Weights: (5.28677025801808,
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Epoch 417/1000, MSE: 0.4655256963431954, Weights: (5.286480697622118,
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Epoch 418/1000, MSE: 0.4643596000961937, Weights: (5.286184255903952,
18.73650533271626)
Epoch 419/1000, MSE: 0.4632146939617425, Weights: (5.285881010778664,
18.738884150132897)
Epoch 420/1000, MSE: 0.46209052025769404, Weights: (5.28557103931022,
18.741240082984582)
Epoch 421/1000, MSE: 0.46098663123595646, Weights: (5.285254417720754,
18.743573380160104)
```
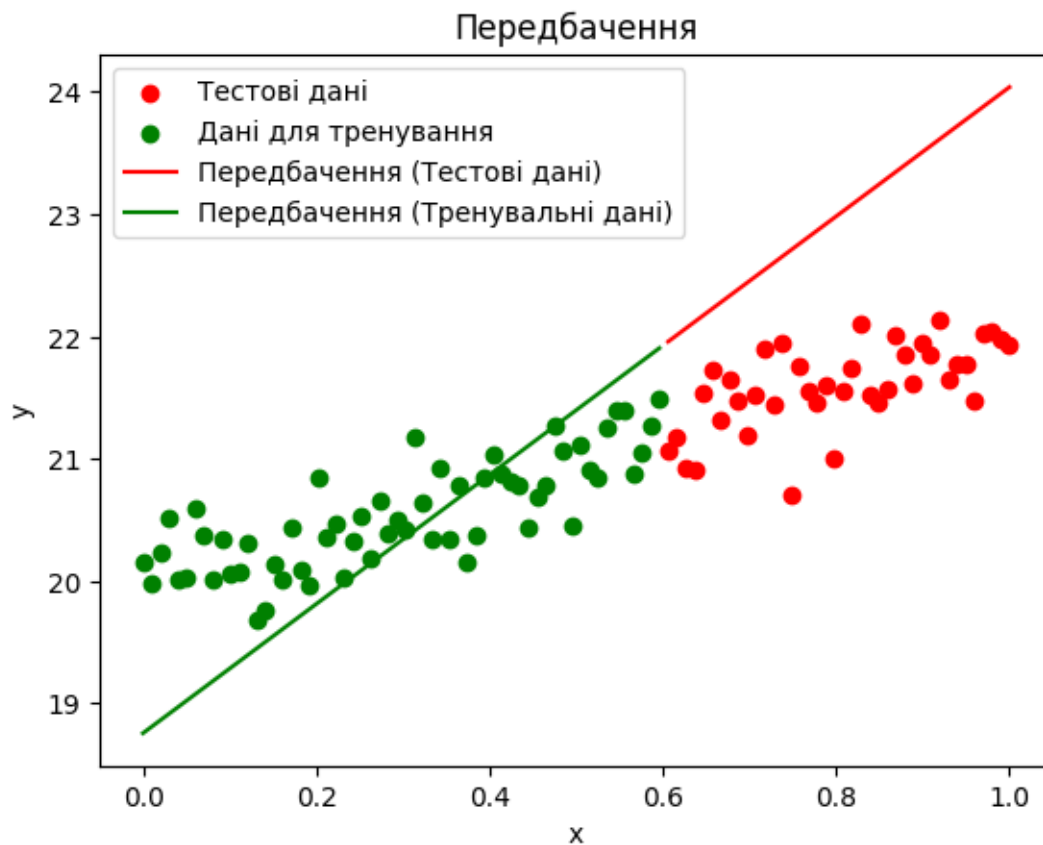
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Epoch 422/1000, MSE: 0.4599025888668378, Weights: (5.28493122139976,
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Epoch 423/1000, MSE: 0.4588379646280855, Weights: (5.2846015249131755,
18.748173049487406)
Epoch 424/1000, MSE: 0.45779233929849816, Weights: (5.284265402012373,
18.75043990595494)
Epoch 425/1000, MSE: 0.4567653027560187, Weights: (5.283922925643048,
18.752685095436142)
Epoch 426/1000, MSE: 0.45575645378021246, Weights: (5.283574167954012,
18.754908853532925)
Epoch 427/1000, MSE: 0.45476539985903003, Weights: (5.283219200305892,
18.7571114132762)
Converged.
```

```python
test_data = np.loadtxt('lab_1_test.csv', delimiter=',', skiprows=1)
x_test = test_data[:, 1]
y_test = test_data[:, 2]

#
predictions_test = linear_regression(x_test, m, b)

#
predictions_train = linear_regression(x_train, m, b)

# d.                        lab1_train.csv,  lab1_test.csv        ,              ⌴
 ↪      ,   .
plt.scatter(x_test, y_test, color='red', label='        ')
plt.scatter(x_train, y_train, color='green', label='            ')
plt.plot(x_test, predictions_test, color='red', label='        (       )')
plt.plot(x_train, predictions_train, color='green', label='        (          )')
plt.xlabel('x')
plt.ylabel('y')
plt.title('        ')
plt.legend()
plt.show()
```

Передбачення

```
[6]:  # c.              ,                      ,                                  lab1_test.csv.
      mse_test = mean_squared_error(predictions_test, y_test)
      print(f'Mean Squared Error on Test Set: {mse_test}')
```

Mean Squared Error on Test Set: 2.196902572823799