```
In [0]: import numpy as np
        import pandas as pd
        from sklearn.datasets import make_classification
```

```
In [0]: X, y = make_classification(n_samples=50000, n_features=15, n_informative=10, n_r
        edundant=5,
                                   n_classes=2, weights=[0.7], class_sep=0.7, random_sta
        te=15)
```

```
In [73]: X.shape, y.shape
```

```
Out[73]: ((50000, 15), (50000,))
```

```
In [0]: from sklearn.model_selection import train_test_split
```

```
In [0]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random
        _state=15)
```

```
In [76]: X_train.shape, y_train.shape, X_test.shape, y_test.shape
```

```
Out[76]: ((37500, 15), (37500,), (12500, 15), (12500,))
```

```
In [0]: from sklearn import linear_model
```

```
In [78]: # alpha : float
         # Constant that multiplies the regularization term.

         # eta0 : double
         # The initial learning rate for the ‘constant’, ‘invscaling’ or ‘adaptive’ sched
         ules.

         clf = linear_model.SGDClassifier(eta0=0.0001, alpha=0.0001, loss='log', random_s
         tate=15, penalty='l2', tol=1e-3, verbose=2, learning_rate='constant')
         clf
```

```
Out[78]: SGDClassifier(alpha=0.0001, average=False, class_weight=None,
                       early_stopping=False, epsilon=0.1, eta0=0.0001,
                       fit_intercept=True, l1_ratio=0.15, learning_rate='constant',
                       loss='log', max_iter=1000, n_iter_no_change=5, n_jobs=None,
                       penalty='l2', power_t=0.5, random_state=15, shuffle=True,
                       tol=0.001, validation_fraction=0.1, verbose=2, warm_start=False)
```

In [79]:
```
clf.fit(X=X_train, y=y_train)
```

```
-- Epoch 1
Norm: 0.77, NNZs: 15, Bias: -0.316653, T: 37500, Avg. loss: 0.455552
Total training time: 0.01 seconds.
-- Epoch 2
Norm: 0.91, NNZs: 15, Bias: -0.472747, T: 75000, Avg. loss: 0.394686
Total training time: 0.02 seconds.
-- Epoch 3
Norm: 0.98, NNZs: 15, Bias: -0.580082, T: 112500, Avg. loss: 0.385711
Total training time: 0.03 seconds.
-- Epoch 4
Norm: 1.02, NNZs: 15, Bias: -0.658292, T: 150000, Avg. loss: 0.382083
Total training time: 0.04 seconds.
-- Epoch 5
Norm: 1.04, NNZs: 15, Bias: -0.719528, T: 187500, Avg. loss: 0.380486
Total training time: 0.04 seconds.
-- Epoch 6
Norm: 1.05, NNZs: 15, Bias: -0.763409, T: 225000, Avg. loss: 0.379578
Total training time: 0.05 seconds.
-- Epoch 7
Norm: 1.06, NNZs: 15, Bias: -0.795106, T: 262500, Avg. loss: 0.379150
Total training time: 0.06 seconds.
-- Epoch 8
Norm: 1.06, NNZs: 15, Bias: -0.819925, T: 300000, Avg. loss: 0.378856
Total training time: 0.07 seconds.
-- Epoch 9
Norm: 1.07, NNZs: 15, Bias: -0.837805, T: 337500, Avg. loss: 0.378585
Total training time: 0.08 seconds.
-- Epoch 10
Norm: 1.08, NNZs: 15, Bias: -0.853138, T: 375000, Avg. loss: 0.378630
Total training time: 0.08 seconds.
Convergence after 10 epochs took 0.08 seconds
```

Out[79]:
```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0001,
              fit_intercept=True, l1_ratio=0.15, learning_rate='constant',
              loss='log', max_iter=1000, n_iter_no_change=5, n_jobs=None,
              penalty='l2', power_t=0.5, random_state=15, shuffle=True,
              tol=0.001, validation_fraction=0.1, verbose=2, warm_start=False)
```

In [80]:
```
clf.coef_, clf.coef_.shape, clf.intercept_
```

Out[80]:
```
(array([[-0.42336692,  0.18547565, -0.14859036,  0.34144407, -0.2081867 ,
          0.56016579, -0.45242483, -0.09408813,  0.2092732 ,  0.18084126,
          0.19705191,  0.00421916, -0.0796037 ,  0.33852802,  0.02266721]]),
 (1, 15),
 array([-0.8531383]))
```

Implement Logistc Regression with L2 regularization Using SGD: without using sklearn

Instructions

- Load the datasets(train and test) into the respective arrays

- Initialize the weight_vector and intercept term randomly

- Calculate the initlal log loss for the train and test data with the current weight and intercept and store it in a list

- for each epoch:
  - for each batch of data points in train: (keep batch size=1)
    - calculate the gradient of loss function w.r.t each weight in weight vector
    - Calculate the gradient of the intercept check this (https://drive.google.com/file/d/1nQ08-XY4zvOLzRX-lGf8EYB5arb7-m1H/view?usp=sharing)
    - Update weights and intercept (check the equation number 32 in the above mentioned pdf (https://drive.google.com/file/d/1nQ08-XY4zvOLzRX-lGf8EYB5arb7-m1H/view?usp=sharing)):
      $w^{(t+1)} \leftarrow (1 - \frac{\alpha\lambda}{N})w^{(t)} + \alpha x_n(y_n - \sigma((w^{(t)})^{T} x_n+b^{t}))$
      $b^{(t+1)} \leftarrow (b^t + \alpha(y_n - \sigma((w^{(t)})^{T} x_n+b^{t}))$
    - calculate the log loss for train and test with the updated weights (you can check the python assignment 10th question)
    - And if you wish, you can compare the previous loss and the current loss, if it is not updating, then you can stop the training
    - append this loss in the list (this will be used to see how loss is changing for each epoch after the training is over)

- Plot the train and test loss i.e on x-axis the epoch number, and on y-axis the loss

- **GOAL**: compare your implementation and SGDClassifier's the weights and intercept, make sure they are as close as possible i.e difference should be in terms of 10^-3

In [81]:

```
w = np.zeros_like(X_train[0])
b = 0
eta0 = 0.0001
alpha = 0.0001
N = len(X_train)
print(len(X_train[0]))
print(len(w))
```

```
15
15
```

In [0]:

```
#here is the sigmoid function
def sigmoid(x,w,b):
  z = np.dot(x,w.T)+b
  return 1.0/(1+np.exp(-z))
```

In [0]:

```
#here is the  log_loss function
def log_loss(X,Y,W,B):
    Sum=0
    for i in range(0,len(X)):
      y_score=sigmoid(X[i],W,B)
      Sum=Sum+Y[i]*np.log(y_score)+(1-Y[i])*np.log(1-y_score)
    return Sum*(-1/len(X))
```

In [84]:

```
#calculating intial los_loss for train and test data.
intial_train_log_loss =log_loss(X_train,y_train,w,b)
intial_test_log_loss = log_loss(X_test,y_test,w,b)
print("intial_train_log_loss == ",intial_train_log_loss)
print("intial_test_log_loss == ",intial_test_log_loss)
```

```
intial_train_log_loss ==  0.6931471805594285
intial_test_log_loss ==  0.6931471805600673
```

In [85]:

```
# findind optimal w and b
import random
Train_loss=[]
Test_loss=[]
for epoch in range(0,25):

  for i in range(0,N):
      w = (1-((alpha*eta0)/N))*w+(alpha*X_train[i])*(y_train[i]-sigmoid(X_train[i],w,b))
      b = b+(alpha)*(y_train[i]-sigmoid(X_train[i],w,b))

  train_loss = log_loss(X_train,y_train,w,b)
  print("train log_loss for epoch",epoch," == ",train_loss)
  Train_loss.append(train_loss)
  test_loss = log_loss(X_test,y_test,w,b)
  print('--'*50)
  print("test log_loss for epoch",epoch,"==",test_loss)
  print("--"*50)
  Test_loss.append(test_loss)


print("optomized w",w)
print("optimized b",b)
```

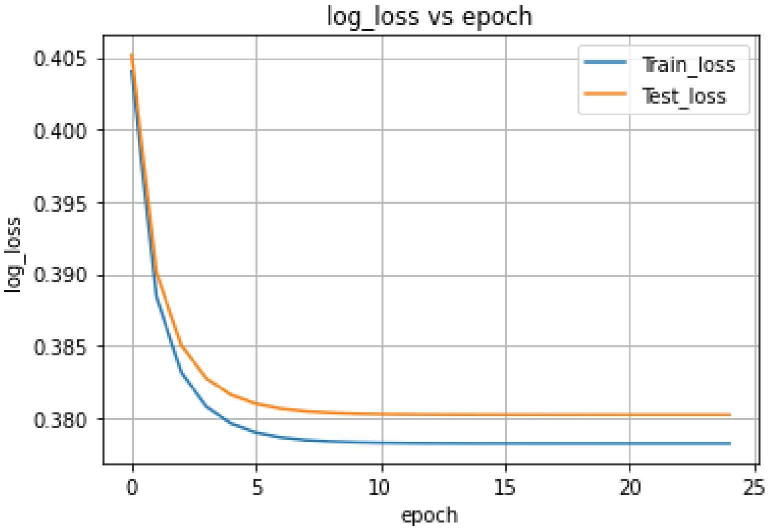
```
train log_loss for epoch 0  ==  0.40403290750563464
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 0 == 0.4051787115691764
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 1  ==  0.388404070036009
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 1 == 0.390080701406506
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 2  ==  0.38314908600186265
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 2 == 0.3850248161373018
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 3  ==  0.3807878200398666
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 3 == 0.38274328047897416
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 4  ==  0.3796069876788165
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 4 == 0.38159369360985645
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 5  ==  0.37898511706106136
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 5 == 0.3809828931580255
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 6  ==  0.37864814221008164
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 6 == 0.3806487512719458
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 7  ==  0.37846236154083357
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 7 == 0.38046266423049313
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 8  ==  0.378358763362984
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 8 == 0.38035776536048627
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 9  ==  0.37830052188546714
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 9 == 0.38029808814707217
```

```
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 10  ==  0.3782675741480116
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 10 == 0.38026387516983073
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 11  ==  0.3782488384285893
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 11 == 0.38024412027243043
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 12  ==  0.3782381345869121
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 12 == 0.3802326309692096
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 13  ==  0.378231991551629
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 13 == 0.3802258965686224
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 14  ==  0.3782284491330998
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 14 == 0.3802219143378415
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 15  ==  0.3782263954690964
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 15 == 0.38021953547679066
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 16  ==  0.37822519749393685
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 16 == 0.38021809752952734
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 17  ==  0.3782244935019806
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 17 == 0.3802172164027742
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 18  ==  0.378224076120547
-------------------------------------------------------------------------------
---------------------
test log_loss for epoch 18 == 0.3802166680599804
-------------------------------------------------------------------------------
---------------------
train log_loss for epoch 19  ==  0.3782238260258433
-------------------------------------------------------------------------------
```

```
--------------------
test log_loss for epoch 19 == 0.38021632092120833
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 20  ==  0.37822367427659426
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 20 == 0.38021609707902754
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 21  ==  0.3782235808490689
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 21 == 0.3802159499590507
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 22  ==  0.3782235223727262
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 22 == 0.3802158513994314
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 23  ==  0.3782234851045095
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 23 == 0.3802157841437289
--------------------------------------------------------------------------------
--------------------
train log_loss for epoch 24  ==  0.3782234608930447
--------------------------------------------------------------------------------
--------------------
test log_loss for epoch 24 == 0.3802157374558484
--------------------------------------------------------------------------------
--------------------
optomized w [-4.29657219e-01  1.92993106e-01 -1.48427055e-01  3.38103883e-01
 -2.21092230e-01  5.69863286e-01 -4.45184638e-01 -8.99472184e-02
  2.21747438e-01  1.73749475e-01  1.98675572e-01 -5.17009955e-04
 -8.12587576e-02  3.39089377e-01  2.29658236e-02]
optimized b -0.8912724453007421
```

In [86]:

```
#plot log_loss vs epoch
import matplotlib.pyplot as plt
a=list(range(0,25))
plt.plot(a,Train_loss,label='Train_loss ')
plt.plot(a,Test_loss,label='Test_loss')
plt.xlabel("epoch")
plt.ylabel("log_loss")
plt.title("log_loss vs epoch")
plt.legend()
plt.grid()
plt.show()
```



In [87]:

```
# these are the results we got after we implemented sgd and found the optimal we
ights and intercept
w-clf.coef_, b-clf.intercept_
```

Out[87]:

```
(array([[-0.0062903 ,  0.00751745,  0.0001633 , -0.00334019, -0.01290553,
          0.0096975 ,  0.00724019,  0.00414091,  0.01247424, -0.00709179,
          0.00162367, -0.00473617, -0.00165506,  0.00056136,  0.00029861]]),
 array([-0.03813415]))
```

In [88]:

```
def pred(w,b, X):
    N = len(X)
    predict = []
    for i in range(N):
        if sigmoid(w, X[i], b) >= 0.5: # sigmoid(w,x,b) returns 1/(1+exp(-(dot
(x,w)+b)))
            predict.append(1)
        else:
            predict.append(0)
    return np.array(predict)
print(1-np.sum(y_train - pred(w,b,X_train))/len(X_train))
print(1-np.sum(y_test  - pred(w,b,X_test))/len(X_test))
```

```
0.95224
0.95
```