

# 16장. 로지스틱 회귀 분석 과제

In [1]:

```
import matplotlib.pyplot as plt
import os
from typing import List, Tuple
import csv
from scratch.linear_algebra import Vector, get_column
```

## 1. 데이터셋

### 1.1 데이터셋 다운로드

In [2]:

```
import requests

data = requests.get("https://archive.ics.uci.edu/ml/machine-learning-databases/breast-cancer-wisconsin/
dataset_path = os.path.join('data', 'wdbc.data')

with open(dataset_path, "w") as f:
    f.write(data.text)
```

### 1.2 데이터 파싱

In [3]:

```
def parse_cancer_row(row: List[str]) -> Tuple[Vector, int]:
    measurements = [float(value) for value in row[2:]]
    label = row[1]
    label = 1 if label == 'M' else 0
    return measurements, label
```

### 1.3 데이터 읽기

위스콘신 유방암 진단 데이터셋 (Wisconsin Breast Cancer Diagnostic dataset)

<https://www.kaggle.com/uciml/breast-cancer-wisconsin-data> (<https://www.kaggle.com/uciml/breast-cancer-wisconsin-data>)

In [4]:

```
X_cancer : List[Vector] = []
y_cancer : List[int] = []
with open(dataset_path) as f:
    reader = csv.reader(f)
    for row in reader:
        x, y = parse_cancer_row(row)
        X_cancer.append(x)
        y_cancer.append(y)
```

In [5]:

```
print(X_cancer[0])
print(y_cancer[0])
```

```
[17.99, 10.38, 122.8, 1001.0, 0.1184, 0.2776, 0.3001, 0.1471, 0.2419, 0.07871, 1.09
5, 0.9053, 8.589, 153.4, 0.006399, 0.04904, 0.05373, 0.01587, 0.03003, 0.006193, 25.
38, 17.33, 184.6, 2019.0, 0.1622, 0.6656, 0.7119, 0.2654, 0.4601, 0.1189]
1
```

## 1.4 데이터 컬럼명

In [6]:

```
columns = [
    "radius_mean", "texture_mean", "perimeter_mean", "area_mean", "smoothness_mean",
    "compactness_mean", "concavity_mean", "points_mean", "symmetry_mean", "dimension_mean",
    "radius_se", "texture_se", "perimeter_se", "area_se", "smoothness_se",
    "compactness_se", "concavity_se", "points_se", "symmetry_se", "dimension_se",
    "radius_worst", "texture_worst", "perimeter_worst", "area_worst", "smoothness_worst",
    "compactness_worst", "concavity_worst", "points_worst", "symmetry_worst", "dimension_worst",
]
```

# 2. 데이터 탐색

## 2.1 클래스 비율 확인

In [7]:

```
from collections import defaultdict
label_type = defaultdict(int)
for y in y_cancer:
    label = 'M' if y == 1 else 'B'
    label_type[label] += 1
```

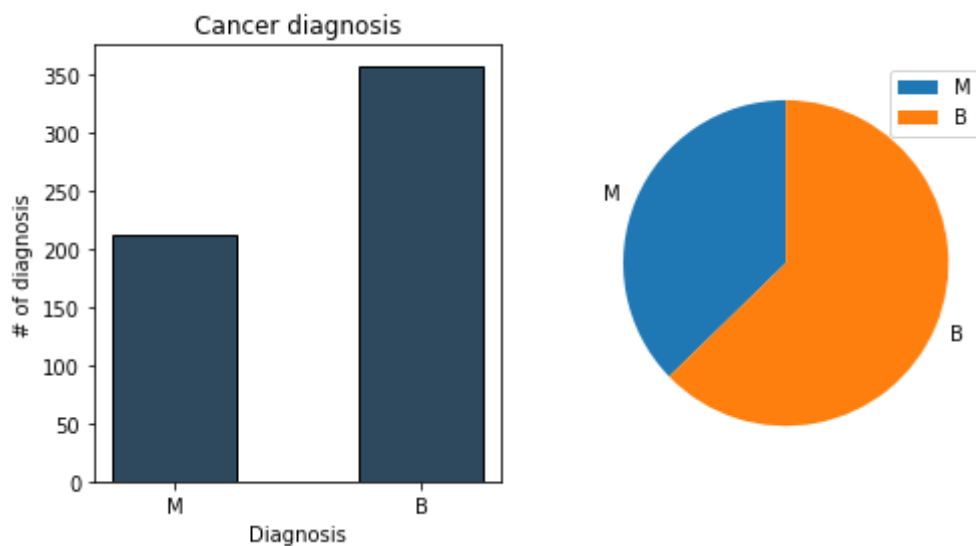
In [8]:

```
plt.figure(figsize=(8,4))
plt.subplot(1, 2, 1)
plt.bar(label_type.keys(),
        label_type.values(),
        0.5,
        facecolor="#2E495E",
        edgecolor=(0, 0, 0))           # Black edges for each bar

plt.xlabel("Diagnosis")
plt.ylabel("# of diagnosis")
plt.title("Cancer diagnosis")

plt.subplot(1, 2, 2)
pies = plt.pie(label_type.values(),
               labels=label_type.keys(),
               startangle=90)

plt.legend()
plt.show()
```



## 2.2 특징 별 히스토그램

In [9]:

```
def histogram(ax, col : int):
    n, bins, patches = ax.hist(get_column(X_cancer, col),
                               8,
                               facecolor="#2E495E",
                               edgecolor=(0, 0, 0))

    ax.set_title(columns[col], fontsize=8)
```

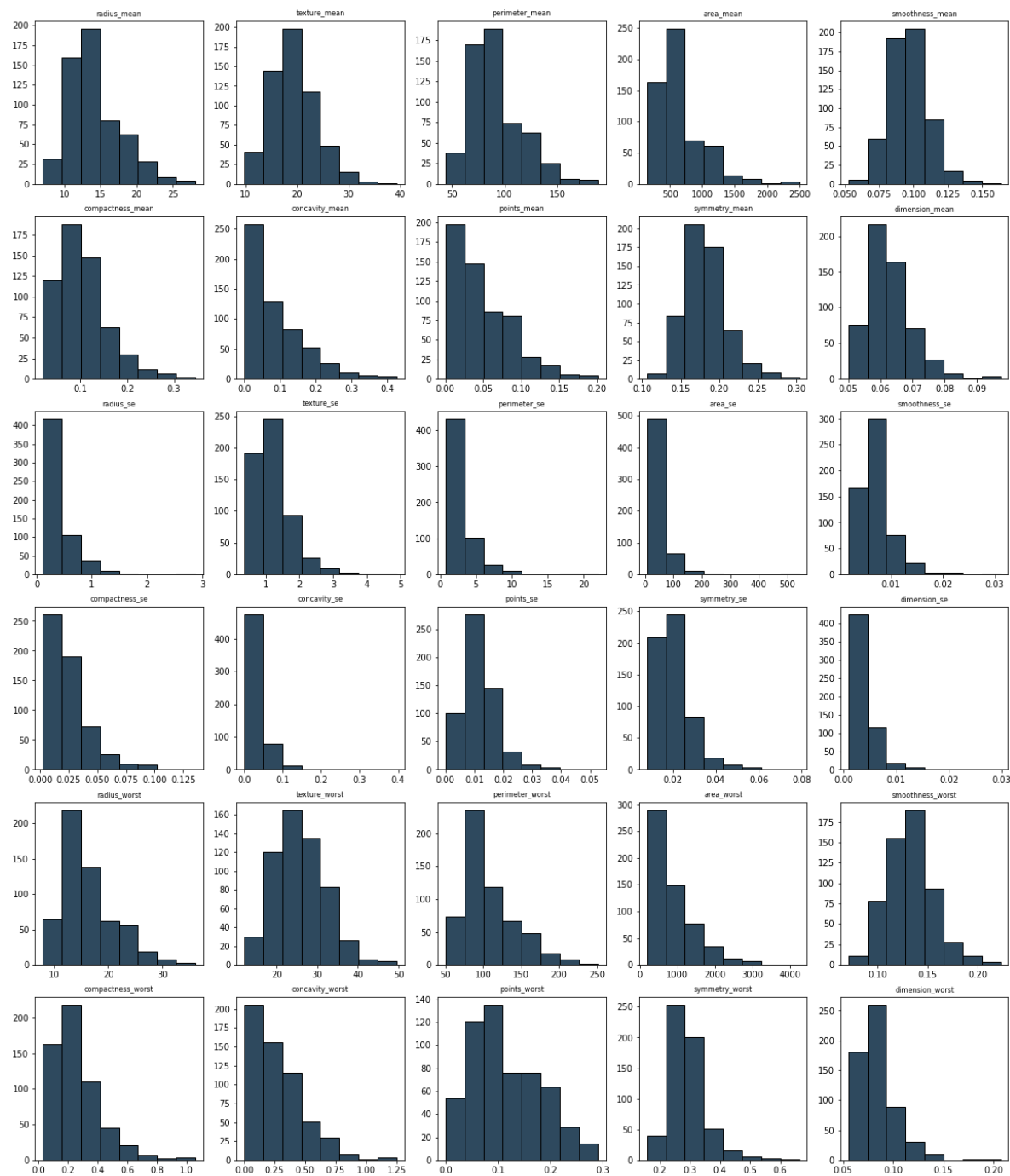
In [10]:

```

from matplotlib import pyplot as plt
num_rows = 6
num_cols = 5

fig, ax = plt.subplots(num_rows, num_cols, figsize=(num_cols*4, num_rows*4))
for row in range(num_rows):
    for col in range(num_cols):
        histogram(ax[row][col], num_cols * row + col)
plt.show()

```



## 2.3 특징 쌍 별 산포도

In [11]:

```
from typing import Dict
points_by_diagnosis: Dict[str, List[Vector]] = defaultdict(list)
for i, x in enumerate(X_cancer):
    y = y_cancer[i]
    label = 'M' if y == 1 else 'B'
    points_by_diagnosis[label].append(x)
```

In [12]:

```
start = 0
end = start + 10
pairs = [(i, j) for i in range(start, end) for j in range(i+1, end) if i < j]
print(pairs)
marks = ['+', '.']
```

```
[(0, 1), (0, 2), (0, 3), (0, 4), (0, 5), (0, 6), (0, 7), (0, 8), (0, 9), (1, 2), (1,
3), (1, 4), (1, 5), (1, 6), (1, 7), (1, 8), (1, 9), (2, 3), (2, 4), (2, 5), (2, 6),
(2, 7), (2, 8), (2, 9), (3, 4), (3, 5), (3, 6), (3, 7), (3, 8), (3, 9), (4, 5), (4,
6), (4, 7), (4, 8), (4, 9), (5, 6), (5, 7), (5, 8), (5, 9), (6, 7), (6, 8), (6, 9),
(7, 8), (7, 9), (8, 9)]
```

In [13]:

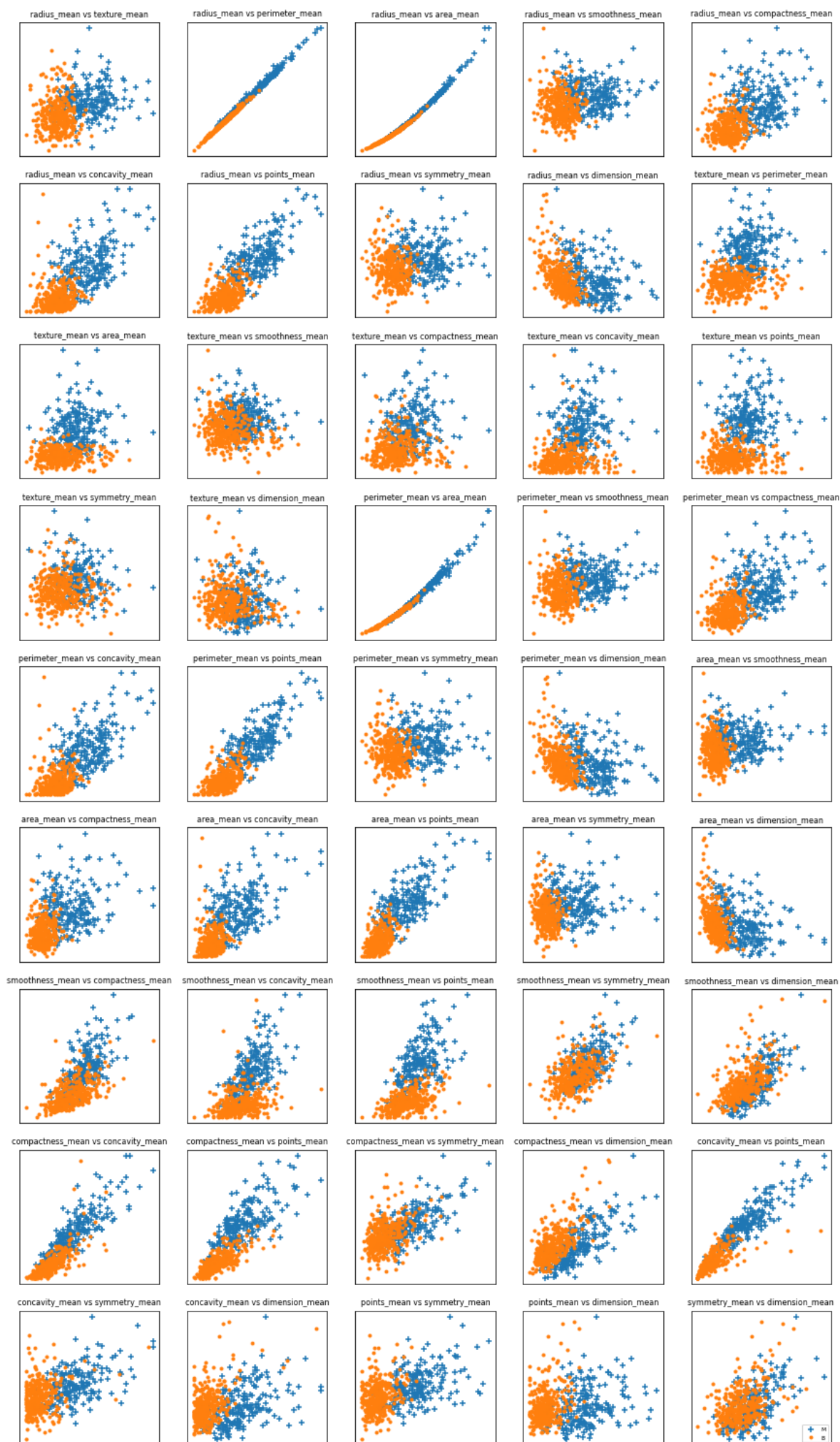
```
from matplotlib import pyplot as plt
num_rows = 9
num_cols = 5

fig, ax = plt.subplots(num_rows, num_cols, figsize=(num_cols*3, num_rows*3))

for row in range(num_rows):
    for col in range(num_cols):
        i, j = pairs[num_cols * row + col]
        ax[row][col].set_title(f"{columns[i]} vs {columns[j]}", fontsize=8)
        ax[row][col].set_xticks([])
        ax[row][col].set_yticks([])

        for mark, (diagnosis, points) in zip(marks, points_by_diagnosis.items()):
            xs = [point[i] for point in points]
            ys = [point[j] for point in points]
            ax[row][col].scatter(xs, ys, marker=mark, label=diagnosis)

ax[-1][-1].legend(loc='lower right', prop={'size': 6})
plt.show()
```



## 3. 데이터 전처리

### 3.1 데이터셋 분리

입력 데이터에 상수 항에 대한 입력 1 추가

In [14]:

```
X_cancer = [[1.0] + row for row in X_cancer]
```

In [15]:

```
import random
from scratch.machine_learning import train_test_split

random.seed(12)
X_train, X_test, y_train, y_test = train_test_split(X_cancer, y_cancer, 0.25)
print('train dataset :', len(X_train))
print('test dataset :', len(X_test))
```

train dataset : 426

test dataset : 143

### 3.2 데이터 표준화 (Standardization) (Q1)

훈련 데이터의 평균과 표준 편차로 테스트 데이터를 표준화 하도록 `normalization()` 함수를 작성해 보시오.



In [16]:

```

from scratch.working_with_data import scale, rescale
from typing import List

def normalization(data: List[Vector],
                  means : Vector = None,
                  stdevs : Vector = None) -> List[Vector]:
    # your code
    dim = len(data[0])

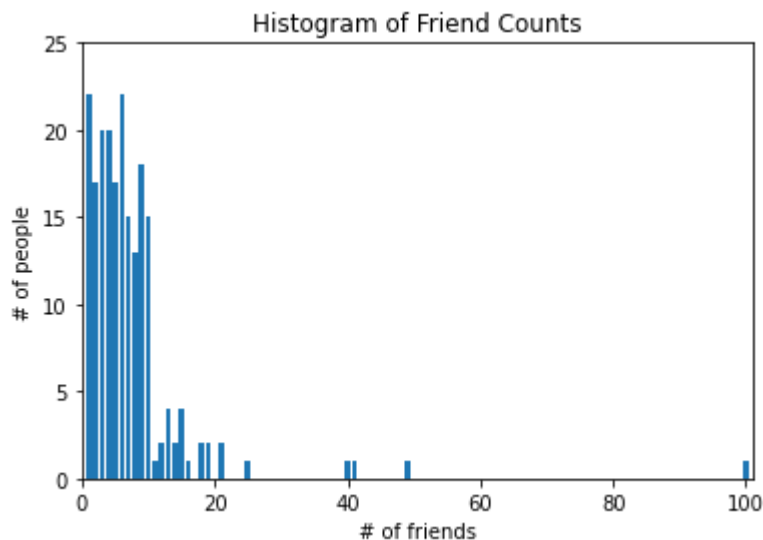
    if means == None or stdevs == None:
        means, stdevs = scale(data)

    rescaled = [v[:] for v in data]

    for v in rescaled:
        for i in range(dim):
            if stdevs[i] > 0:
                v[i] = (v[i] - means[i]) / stdevs[i]

    return rescaled, means, stdevs

```



In [17]:

```

X_train_normed, X_train_means, X_train_stdevs = normalization(X_train)
X_test_normed, _, _ = normalization(X_test, X_train_means, X_train_stdevs)

```

## 4. 로지스틱 회귀

### 4.1 로지스틱 함수 (Logistic Function) (Q2)

로지스틱 함수와 미분을 구현해 보시오.

In [18]:

```
# your code
from matplotlib import pyplot as plt
import math

def logistic(x: float) -> float:
    return 1.0 / (1 + math.exp(-x))
```

In [19]:

```
import math

def logistic_prime(x: float) -> float:
    y = logistic(x)
    return y * (1-y)
```

## 4.2 손실 함수 (Q3)

베르누이 분포의 음의 로그 우도(NLL)로 정의되는 손실 함수를 구현해 보시오.

In [20]:

```
# your code
import math
from scratch.linear_algebra import Vector, dot

def _negative_log_likelihood(x: Vector, y: float, beta: Vector) -> float:
    if y == 1:
        return -math.log(logistic(dot(x, beta)))
    else:
        return -math.log(1 - logistic(dot(x, beta)))
```

In [21]:

```
from typing import List
import math
from scratch.linear_algebra import Vector, dot

def negative_log_likelihood(xs: List[Vector],
                           ys: List[float],
                           beta: Vector) -> float:
    return sum(_negative_log_likelihood(x, y, beta) for x, y in zip(xs, ys))
```

## 4.3 손실 함수 미분 (Q4)

NLL의 그래디언트를 구현해 보시오.

In [22]:

```
from scratch.linear_algebra import vector_sum
import math

def _negative_log_partial_j(x: Vector, y: float, beta: Vector, j: int) -> float:
    return -(y - logistic(dot(x, beta))) * x[j]
```

In [23]:

```
# your code
from scratch.linear_algebra import vector_sum
import math

def _negative_log_gradient(x: Vector, y: float, beta: Vector) -> Vector:
    return [_negative_log_partial_j(x, y, beta, j) for j in range(len(beta))]
```

In [24]:

```
import math
def negative_log_gradient(xs: List[Vector],
                        ys: List[float],
                        beta: Vector) -> Vector:
    return vector_sum([_negative_log_gradient(x, y, beta) for x,y in zip(xs, ys)])
```

## 4.4 모델 훈련 (Q5)

로지스틱 회귀 모델 학습을 경사 하강법으로 구현하시오.

In [25]:

```
import random
import math
import tqdm
import IPython.display as display
from scratch.linear_algebra import vector_mean
from scratch.gradient_descent import gradient_step

def logistic_regression(xs: List[Vector],
                      ys: List[float],
                      learning_rate: float = 0.001,
                      num_steps: int = 1000,
                      batch_size: int = 1) -> Vector:

    # your code
    learning_rate = 0.01
    beta = [random.random() for _ in xs[0]]
    history = []

    for i in tqdm.trange(num_steps):
        for epoch in range(0, len(xs), batch_size):
            batch_xs = xs[epoch:epoch+batch_size]
            batch_ys = ys[epoch:epoch+batch_size]
            gradient = negative_log_gradient(batch_xs, batch_ys, beta)
            beta = gradient_step(beta, gradient, -learning_rate)
            loss = negative_log_likelihood(batch_xs, batch_ys, beta)
            #epoch.set_description(f"loss: {loss:.3f} beta: {beta}")

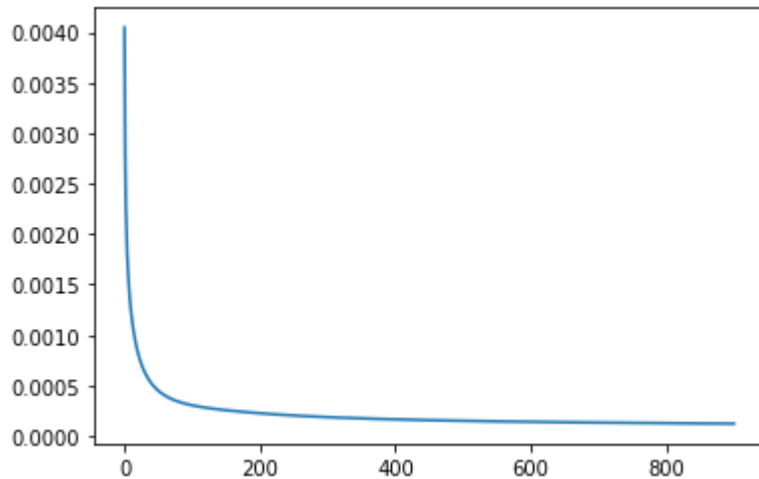
        history.append(loss)

        if i and i % 100 == 0:
            display.clear_output(wait=True)
            plt.plot(history)
            plt.show()
    #print(history)

    return beta
```

In [26]:

```
beta = logistic_regression(X_train_normed, y_train)
```

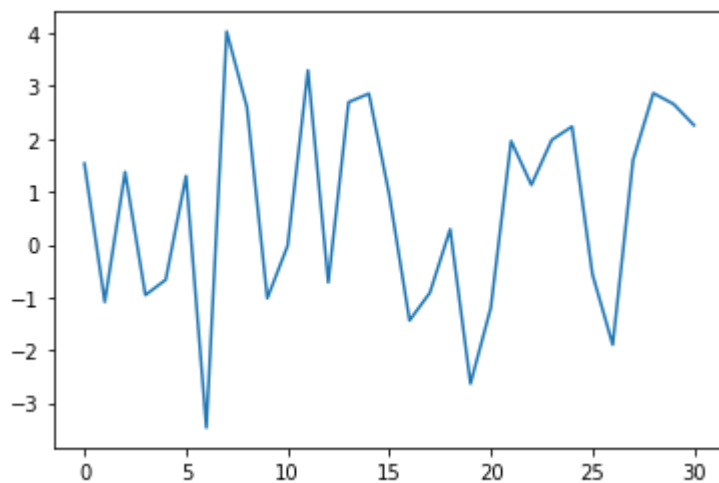


100%|██████████| 1000/1000 [00:46&lt;00:00, 21.62it/s]

### $\beta$ 확인

In [27]:

```
plt.plot(beta)  
plt.show()
```



## 3.7 모델 테스트 (Q6)

테스트 데이터를 이용해서 모델 예측을 해보고 TP, FP, FN, TN을 계산해 보시오.

In [28]:

```
# your code
TP = FP = TN = FN = 0

for x_i, y_i in zip(X_train_normed, y_train):
    prediction = logistic(dot(beta, x_i))

    if y_i == 1 and prediction >= 0.5:
        TP += 1
    elif y_i == 1:
        FN += 1
    elif prediction >= 0.5:
        FP += 1
    else:
        TN += 1

precision = TP / (TP + FP)
recall = TP / (TP + FN)

confusion_matrix = [[TP, FP], [FN, TN]]
```

### 3.8 모델 성능

In [29]:

```
from scratch.machine_learning import accuracy, precision, recall, f1_score

print(confusion_matrix)
print("accuracy :", accuracy(TP, FP, FN, TN))
print("precision :", precision(TP, FP, FN, TN))
print("recall :", recall(TP, FP, FN, TN))
print("f1_score :", f1_score(TP, FP, FN, TN))
```

```
[[157, 2], [4, 263]]
accuracy : 0.9859154929577465
precision : 0.9874213836477987
recall : 0.9751552795031055
f1_score : 0.98125
```

In [30]:

```
predictions = [logistic(dot(beta, x)) for x in X_test_normed]
plt.scatter(predictions, y_test, marker='+')
plt.xlabel("predicted probability")
plt.ylabel("actual outcome")
plt.title("Logistic Regression Predicted vs. Actual")
plt.show()
```

