Task 1

Implement the OR Boolean logic gate using perceptron Neural Network. Inputs = x1, x2 and bias, weights should be fed into the perceptron with single Output = y. Display final weights and bias of each perceptron

In [21]:
```
import numpy as np
import tensorflow as tf
```

In [22]:
```
X = np.array([
    [0, 0],
    [0, 1],
    [1, 0],
    [1, 1]
])
y = np.array([0, 1, 1, 1])
w1 = 1
w2 = 1
b = 0
```

In [23]:
```
def step(z):
    return 1 if z>=1 else 0
```

In [24]:
```
for i in range(X.shape[0]):
    z = w1*X[i][0] + w2*X[i][1] + b
    print(f"Input: {X[i]} → Output:", step(z))
```

```
Input: [0 0] → Output: 0
Input: [0 1] → Output: 1
Input: [1 0] → Output: 1
Input: [1 1] → Output: 1
```

Using the updating weights and bias approach:

In [25]:
```
w = np.random.rand(2)
b = np.random.rand(1)

epochs = 5
learning_rate = 0.1

for epoch in range(epochs):
    for i in range(X.shape[0]):
        z = np.dot(w, X[i]) + b
        y_pred = step(z)
        error = y[i] - y_pred
        w += learning_rate * error * X[i]
        b += learning_rate * error

print("Trained weights:", w)
print("Trained bias:", b)
```

```
Trained weights: [0.67763061 0.98066931]
Trained bias: [0.96288341]
```

In [26]:
```
print("\nPredictions:")
for i in range(len(X)):
    z = np.dot(w, X[i]) + b
    print(f"Input: {X[i]} → Output:", step(z))
```

```
Predictions:
Input: [0 0] → Output: 0
Input: [0 1] → Output: 1
Input: [1 0] → Output: 1
Input: [1 1] → Output: 1
```

Task 2

Use the heart disease dataset and do the following
- Use the Dataset
- Create an autoencoder and fit it with our data using 2 neurons in the dense layer
- Plot loss w.r.t. epochs
- Calculate reconstruction error using Mean Squared Error (MSE).

In [27]:
```
import pandas as pd
```

In [28]:
```
X = pd.read_csv('Data/heart.csv')
```

In [29]:
```
X
```

Out[29]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope
0	52	1	0	125	212	0	1	168	0	1.0	2
1	53	1	0	140	203	1	0	155	1	3.1	0
2	70	1	0	145	174	0	1	125	1	2.6	0
3	61	1	0	148	203	0	1	161	0	0.0	2
4	62	0	0	138	294	1	1	106	0	1.9	1
...	...	...	...	...	...	...	...	...	...	...	...
1020	59	1	1	140	221	0	1	164	1	0.0	2
1021	60	1	0	125	258	0	0	141	1	2.8	1
1022	47	1	0	110	275	0	0	118	1	1.0	1
1023	50	0	0	110	254	0	0	159	0	0.0	2
1024	54	1	0	120	188	0	1	113	0	1.4	1

1025 rows × 14 columns

In [30]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

In [31]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Input
```

In [32]:
```
autoencoder = Sequential([
    Input(shape = (X.shape[1], )),
    Dense(2, activation='relu'),
    Dense(X.shape[1], activation='sigmoid')
])
```

In [33]:
```
autoencoder.compile(optimizer='adam', loss='mse')
```

In [34]:
```
autoencoder.fit(X_scaled, X_scaled, epochs=50, batch_size=16, shuffle=True,
validation_split=0.2)
```

```
Epoch 1/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.3091
- val_loss: 1.2259
Epoch 2/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2780
- val_loss: 1.1955
Epoch 3/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2502
- val_loss: 1.1680
Epoch 4/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2253
- val_loss: 1.1423
Epoch 5/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2028
- val_loss: 1.1191
Epoch 6/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1821
- val_loss: 1.0968
Epoch 7/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1622
- val_loss: 1.0754
Epoch 8/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1433
- val_loss: 1.0551
Epoch 9/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1254
- val_loss: 1.0362
Epoch 10/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1087
- val_loss: 1.0190
Epoch 11/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0934
- val_loss: 1.0038
Epoch 12/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0796
- val_loss: 0.9901
Epoch 13/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0669
- val_loss: 0.9782
Epoch 14/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0558
- val_loss: 0.9678
Epoch 15/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0456
- val_loss: 0.9587
Epoch 16/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0364
- val_loss: 0.9506
Epoch 17/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0280
- val_loss: 0.9433
Epoch 18/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0204
- val_loss: 0.9367
Epoch 19/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0132
- val_loss: 0.9300
Epoch 20/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0060
- val_loss: 0.9238
Epoch 21/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9989
- val_loss: 0.9171
Epoch 22/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9917
- val_loss: 0.9107
```

```
Epoch 23/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9845
- val_loss: 0.9043
Epoch 24/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9773
- val_loss: 0.8981
Epoch 25/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9701
- val_loss: 0.8918
Epoch 26/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9631
- val_loss: 0.8860
Epoch 27/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9567
- val_loss: 0.8807
Epoch 28/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9509
- val_loss: 0.8760
Epoch 29/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9459
- val_loss: 0.8720
Epoch 30/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9416
- val_loss: 0.8684
Epoch 31/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9377
- val_loss: 0.8653
Epoch 32/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9341
- val_loss: 0.8624
Epoch 33/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9308
- val_loss: 0.8598
Epoch 34/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9277
- val_loss: 0.8575
Epoch 35/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9248
- val_loss: 0.8552
Epoch 36/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9221
- val_loss: 0.8532
Epoch 37/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9195
- val_loss: 0.8514
Epoch 38/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9171
- val_loss: 0.8496
Epoch 39/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9148
- val_loss: 0.8481
Epoch 40/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9127
- val_loss: 0.8465
Epoch 41/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9107
- val_loss: 0.8452
Epoch 42/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9088
- val_loss: 0.8439
Epoch 43/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9071
- val_loss: 0.8428
Epoch 44/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9054
- val_loss: 0.8417
Epoch 45/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9039
- val_loss: 0.8406
Epoch 46/50
```

```
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9024
- val_loss: 0.8396
Epoch 47/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9009
- val_loss: 0.8386
Epoch 48/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8994
- val_loss: 0.8375
Epoch 49/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8980
- val_loss: 0.8365
Epoch 50/50
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8965
- val_loss: 0.8355
```

Out[34]:
```
<keras.src.callbacks.history.History at 0x1e201a69250>
```

In [35]:
```
encoder  =Sequential([autoencoder.layers[0]])
encoded_data = encoder.predict(X_scaled)
```

```
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 790us/step
```

The reduced dimention values are as follows:

In [36]:
```
encoded_data
```

Out[36]:
```
array([[0.4363609, 0.6735984],
       [0.       , 4.5518847],
       [0.       , 6.68523  ],
       ...,
       [0.       , 7.929942 ],
       [6.1295547, 2.3963432],
       [0.       , 4.846034 ]], shape=(1025, 2), dtype=float32)
```

In [37]:
```
preds = []
loss = []
for i in range(1,8):
    autoencoder = Sequential([
        Input(shape = (X.shape[1], )),
        Dense(i, activation='relu'),
        Dense(X.shape[1], activation='sigmoid')
    ])
    autoencoder.compile(optimizer='adam', loss='mse')
    history = autoencoder.fit(X_scaled, X_scaled, epochs=20, batch_size=16,
shuffle=True, validation_split=0.2)
    preds.append(autoencoder.predict(X_scaled))
    loss.append(history.history['loss'])
    print(f'Encoding Dimension: {i}, Loss: {loss[-1]}')
```

```
  Epoch 1/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.2832
  - val_loss: 1.2033
  Epoch 2/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2611
  - val_loss: 1.1835
  Epoch 3/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2422
  - val_loss: 1.1661
  Epoch 4/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2255
  - val_loss: 1.1510
  Epoch 5/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2104
  - val_loss: 1.1373
  Epoch 6/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1962
  - val_loss: 1.1240
  Epoch 7/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1820
  - val_loss: 1.1110
  Epoch 8/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1676
  - val_loss: 1.0974
  Epoch 9/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1522
  - val_loss: 1.0834
  Epoch 10/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1363
  - val_loss: 1.0688
  Epoch 11/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1201
  - val_loss: 1.0545
  Epoch 12/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1037
  - val_loss: 1.0401
  Epoch 13/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0878
  - val_loss: 1.0263
  Epoch 14/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0732
  - val_loss: 1.0142
  Epoch 15/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0602
  - val_loss: 1.0028
  Epoch 16/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0486
  - val_loss: 0.9930
  Epoch 17/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0384
  - val_loss: 0.9842
  Epoch 18/20
  [1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0296
  - val_loss: 0.9767
```

```
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0220
- val_loss: 0.9700
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0153
- val_loss: 0.9641
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 921us/step
Encoding Dimension: 1, Loss: [1.2831521034240723, 1.2611310482025146,
1.242155909538269, 1.2254847288131714, 1.2104400396347046, 1.1961543560028076,
1.1820470094680786, 1.167638897895813, 1.1521997451782227, 1.1363461017608643,
1.1200652122497559, 1.1037242412567139, 1.087790846824646, 1.0731830596923828,
1.060219407081604, 1.0485895872116089, 1.0384330749511719, 1.0295852422714233,
1.0219604969024658, 1.015328049659729]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.2512
- val_loss: 1.1696
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2222
- val_loss: 1.1436
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1958
- val_loss: 1.1190
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1704
- val_loss: 1.0952
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1457
- val_loss: 1.0711
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1203
- val_loss: 1.0461
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0931
- val_loss: 1.0210
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0659
- val_loss: 0.9969
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0404
- val_loss: 0.9749
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0177
- val_loss: 0.9560
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9980
- val_loss: 0.9394
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9814
- val_loss: 0.9258
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9679
- val_loss: 0.9148
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9566
- val_loss: 0.9056
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9476
- val_loss: 0.8982
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9404
- val_loss: 0.8921
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9345
- val_loss: 0.8873
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9296
- val_loss: 0.8830
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9255
- val_loss: 0.8791
```

```
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9221
- val_loss: 0.8763
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step
Encoding Dimension: 2, Loss: [1.251167893409729, 1.2222402095794678,
1.1958192586898804, 1.170384168624878, 1.1456682682037354, 1.1202806234359741,
1.0931165218353271, 1.065946340560913, 1.0403627157211304, 1.0177333354949951,
0.9980093836784363, 0.9814159274101257, 0.9678815007209778, 0.9565631151199341,
0.9476122856140137, 0.9404034614562988, 0.9344808459281921, 0.9295568466186523,
0.9255173802375793, 0.9221017956733704]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.3033
- val_loss: 1.2059
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2658
- val_loss: 1.1747
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2327
- val_loss: 1.1478
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2021
- val_loss: 1.1230
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1727
- val_loss: 1.0985
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1446
- val_loss: 1.0754
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1184
- val_loss: 1.0542
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0954
- val_loss: 1.0349
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0748
- val_loss: 1.0167
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0566
- val_loss: 1.0007
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0408
- val_loss: 0.9865
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0273
- val_loss: 0.9739
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0156
- val_loss: 0.9631
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0055
- val_loss: 0.9533
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9966
- val_loss: 0.9447
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9887
- val_loss: 0.9369
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9815
- val_loss: 0.9297
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9747
- val_loss: 0.9229
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9685
- val_loss: 0.9167
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9626
- val_loss: 0.9112
```

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[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 919us/step
Encoding Dimension: 3, Loss: [1.3032701015472412, 1.265808343887329,
1.2327265739440918, 1.2021225690841675, 1.172741413116455, 1.1446104049682617,
1.1184163093566895, 1.0954279899597168, 1.0747706890106201, 1.0565791130065918,
1.0407543182373047, 1.0272631645202637, 1.015642523765564, 1.0055080652236938,
0.9966239929199219, 0.9886893630027771, 0.9814791083335876, 0.9747150540351868,
0.9684500098228455, 0.9626489281654358]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 3ms/step - loss: 1.2692
- val_loss: 1.1875
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2315
- val_loss: 1.1521
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1963
- val_loss: 1.1182
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1613
- val_loss: 1.0838
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1242
- val_loss: 1.0485
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0859
- val_loss: 1.0115
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0473
- val_loss: 0.9752
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0111
- val_loss: 0.9429
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9801
- val_loss: 0.9161
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9549
- val_loss: 0.8942
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9347
- val_loss: 0.8771
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9190
- val_loss: 0.8629
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9062
- val_loss: 0.8515
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8958
- val_loss: 0.8420
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8875
- val_loss: 0.8341
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8804
- val_loss: 0.8272
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8743
- val_loss: 0.8214
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8688
- val_loss: 0.8163
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8640
- val_loss: 0.8120
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8596
- val_loss: 0.8076
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 948us/step
Encoding Dimension: 4, Loss: [1.2692148685455322, 1.2314589023590088,
1.1962578296661377, 1.1612668037414455, 1.124210238456726, 1.0859355926513672,
```

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1.0472582578659058, 1.0111247301101685, 0.9801482558250427, 0.9549389481544495,
0.9346714615821838, 0.9189833998680115, 0.9062225818634033, 0.8958492279052734,
0.8874610066413879, 0.8803602457046509, 0.8742563128471375, 0.8688479661941528,
0.864011824131012, 0.8595812320709229]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.2697
- val_loss: 1.1801
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2280
- val_loss: 1.1435
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1900
- val_loss: 1.1098
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1543
- val_loss: 1.0776
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1209
- val_loss: 1.0477
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0899
- val_loss: 1.0198
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0621
- val_loss: 0.9945
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0361
- val_loss: 0.9705
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0115
- val_loss: 0.9474
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9883
- val_loss: 0.9257
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9662
- val_loss: 0.9050
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9453
- val_loss: 0.8863
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9269
- val_loss: 0.8699
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9109
- val_loss: 0.8559
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8972
- val_loss: 0.8441
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8856
- val_loss: 0.8342
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8754
- val_loss: 0.8254
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8664
- val_loss: 0.8175
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8580
- val_loss: 0.8105
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8501
- val_loss: 0.8040
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step
Encoding Dimension: 5, Loss: [1.2697259187698364, 1.2279988527297974,
1.1899957656860352, 1.1543203592300415, 1.1208827495574951, 1.0899039506912231,
1.0621033906936646, 1.03610360622406, 1.011527419090271, 0.9883061647415161,
0.9661586880683899, 0.9453197717666626, 0.9268538355827332, 0.9109323024749756,
0.8972092866897583, 0.8855556845664978, 0.8753909468650818, 0.8663800358772278,
```

```
0.8580005764961243, 0.8500725030899048]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.2689
- val_loss: 1.1872
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.2191
- val_loss: 1.1430
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1739
- val_loss: 1.1030
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1305
- val_loss: 1.0641
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0879
- val_loss: 1.0260
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0468
- val_loss: 0.9906
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0095
- val_loss: 0.9575
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9757
- val_loss: 0.9286
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9462
- val_loss: 0.9031
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9209
- val_loss: 0.8818
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9000
- val_loss: 0.8641
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8829
- val_loss: 0.8494
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8690
- val_loss: 0.8372
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8573
- val_loss: 0.8268
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8473
- val_loss: 0.8179
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8387
- val_loss: 0.8100
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8311
- val_loss: 0.8030
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8246
- val_loss: 0.7963
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8186
- val_loss: 0.7908
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8130
- val_loss: 0.7855
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step
Encoding Dimension: 6, Loss: [1.268891453742981, 1.2191321849822998,
1.173931360244751, 1.1304678916931152, 1.0878806114196777, 1.0468478202819824,
1.0094624757766724, 0.9757015109062195, 0.946201503276825, 0.9208778142929077,
0.8999965786933899, 0.8829025626182556, 0.8690149784088135, 0.8573118448257446,
0.8473080992698669, 0.8387160301208496, 0.8311342000961304, 0.824552059173584,
0.8185542225837708, 0.8130397200584412]
Epoch 1/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 2ms/step - loss: 1.1954
```

```
- val_loss: 1.1067
Epoch 2/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.1404
- val_loss: 1.0555
Epoch 3/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0870
- val_loss: 1.0053
Epoch 4/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 1.0355
- val_loss: 0.9581
Epoch 5/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9879
- val_loss: 0.9176
Epoch 6/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9489
- val_loss: 0.8844
Epoch 7/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.9183
- val_loss: 0.8581
Epoch 8/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8944
- val_loss: 0.8371
Epoch 9/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8755
- val_loss: 0.8200
Epoch 10/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8599
- val_loss: 0.8055
Epoch 11/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8466
- val_loss: 0.7930
Epoch 12/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8349
- val_loss: 0.7820
Epoch 13/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8244
- val_loss: 0.7722
Epoch 14/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8151
- val_loss: 0.7633
Epoch 15/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.8066
- val_loss: 0.7556
Epoch 16/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.7989
- val_loss: 0.7481
Epoch 17/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.7919
- val_loss: 0.7416
Epoch 18/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.7855
- val_loss: 0.7353
Epoch 19/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.7794
- val_loss: 0.7296
Epoch 20/20
[1m52/52[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 1ms/step - loss: 0.7737
- val_loss: 0.7244
[1m33/33[0m [32m━━━━━━━━━━━━━━━━━━━━[0m[37m[0m [1m0s[0m 944us/step
Encoding Dimension: 7, Loss: [1.1954097747802734, 1.140404224395752,
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0.9183225035667419, 0.8943727612495422, 0.8754844069480896, 0.8599272966384888,
0.846598207950592, 0.8348783254623413, 0.824389636516571, 0.8150631785392761,
0.8066068291664124, 0.7989274859428406, 0.791931688785553, 0.7854940891265869,
0.7793994545936584, 0.773716151714325]
```

In [38]:
```
loss
```

Out[38]:
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```

```
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 0.9208778142929077,
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 0.8690149784088135,
 0.8573118448257446,
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[1.1954097747802734,
 1.140404224395752,
 1.0870429277420044,
 1.0354678630828857,
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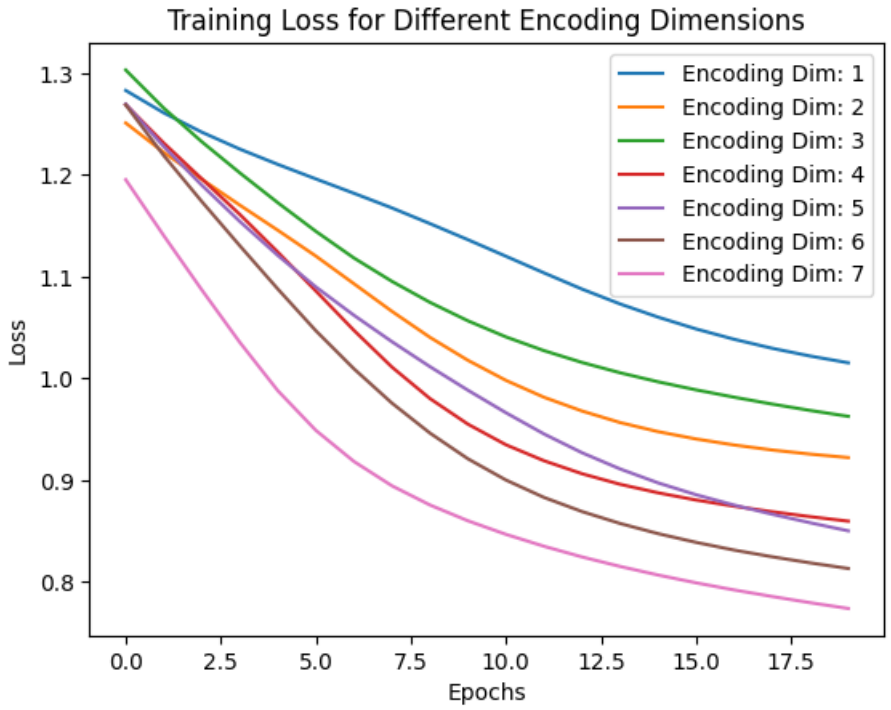
 0.9488819241523743,
 0.9183225035667419,
 0.8943727612495422,
 0.8754844069480896,
 0.8599272966384888,
 0.846598207950592,
 0.8348783254623413,
 0.824389636516571,
 0.8150631785392761,
 0.8066068291664124,
 0.7989274859428406,
 0.791931688785553,
```

```
0.7854940891265869,
0.7793994545936584,
0.773716151714325]]
```

In [39]:
```
import matplotlib.pyplot as plt

for i in range(len(loss)):
    plt.plot(loss[i], label=f'Encoding Dim: {i+1}')
plt.title('Training Loss for Different Encoding Dimensions')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```



In [ ]: