In [1]:
```
import numpy as np
import tensorflow as tf
from tensorflow import keras
import pandas as pd
import seaborn as sns
from pylab import rcParams
import matplotlib.pyplot as plt
from matplotlib import rc
from sklearn.model_selection import train_test_split
import joblib

%matplotlib inline
%config InlineBackend.figure_format='retina'

sns.set(style='whitegrid', palette='muted', font_scale=1.5)

rcParams['figure.figsize'] = 16, 10

RANDOM_SEED = 60

np.random.seed(RANDOM_SEED)
tf.random.set_seed(RANDOM_SEED)
```

In [2]:
```
X_test = pd.read_csv('data/X_test.csv')
X_train = pd.read_csv('data/X_train.csv')
y_train = pd.read_csv('data/y_train.csv')
```

Exploration

In [3]:
```
print(f"Shape x test {X_test.shape}")
print(f"Shape x train {X_train.shape}")
print(f"Shape y train {y_train.shape}")
```

```
Shape x test (3765, 10)
Shape x train (33884, 10)
Shape y train (33884, 2)
```

In [4]:
```
X_test.columns
```

Out[4]:
```
Index(['id', 'latitude', 'longitude', 'minimum_nights', 'number_of_reviews',
       'reviews_per_month', 'calculated_host_listings_count',
       'availability_365', 'Private_room', 'Entire_home/apt'],
      dtype='object')
```

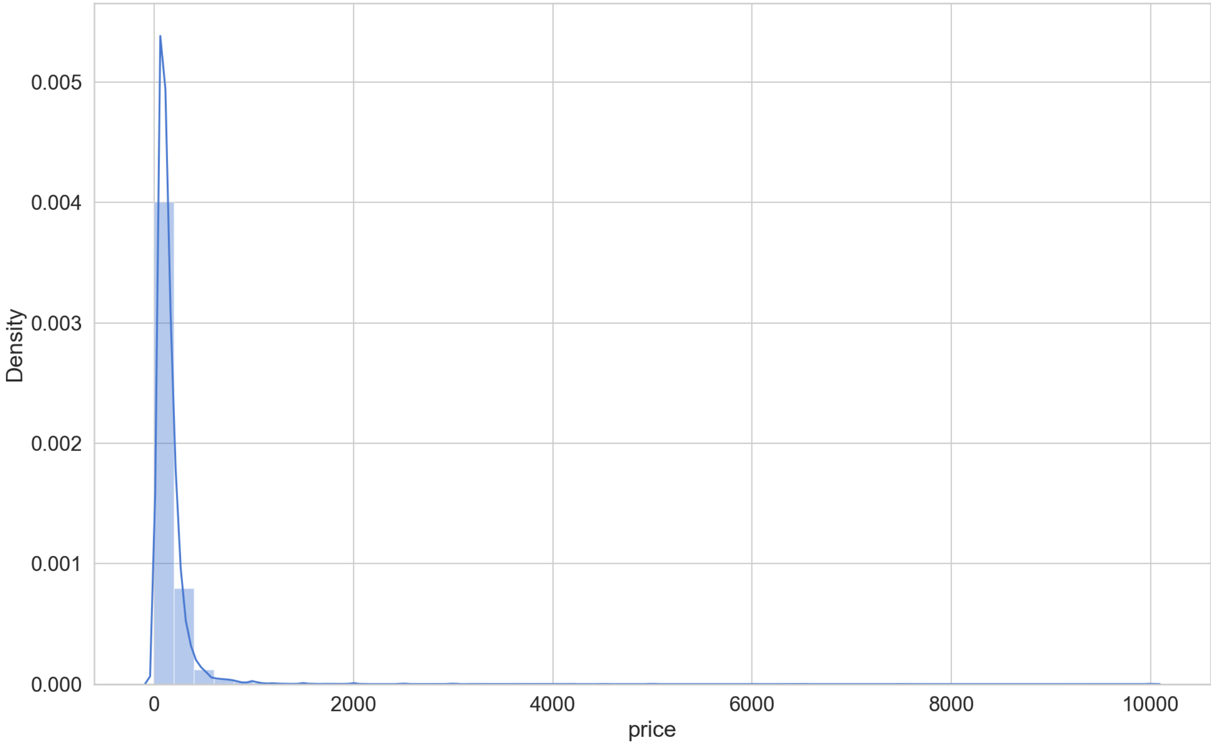
In [5]:
```
X_train.columns
```

Out[5]:
```
Index(['id', 'latitude', 'longitude', 'minimum_nights', 'number_of_reviews',
       'reviews_per_month', 'calculated_host_listings_count',
       'availability_365', 'Private_room', 'Entire_home/apt'],
      dtype='object')
```

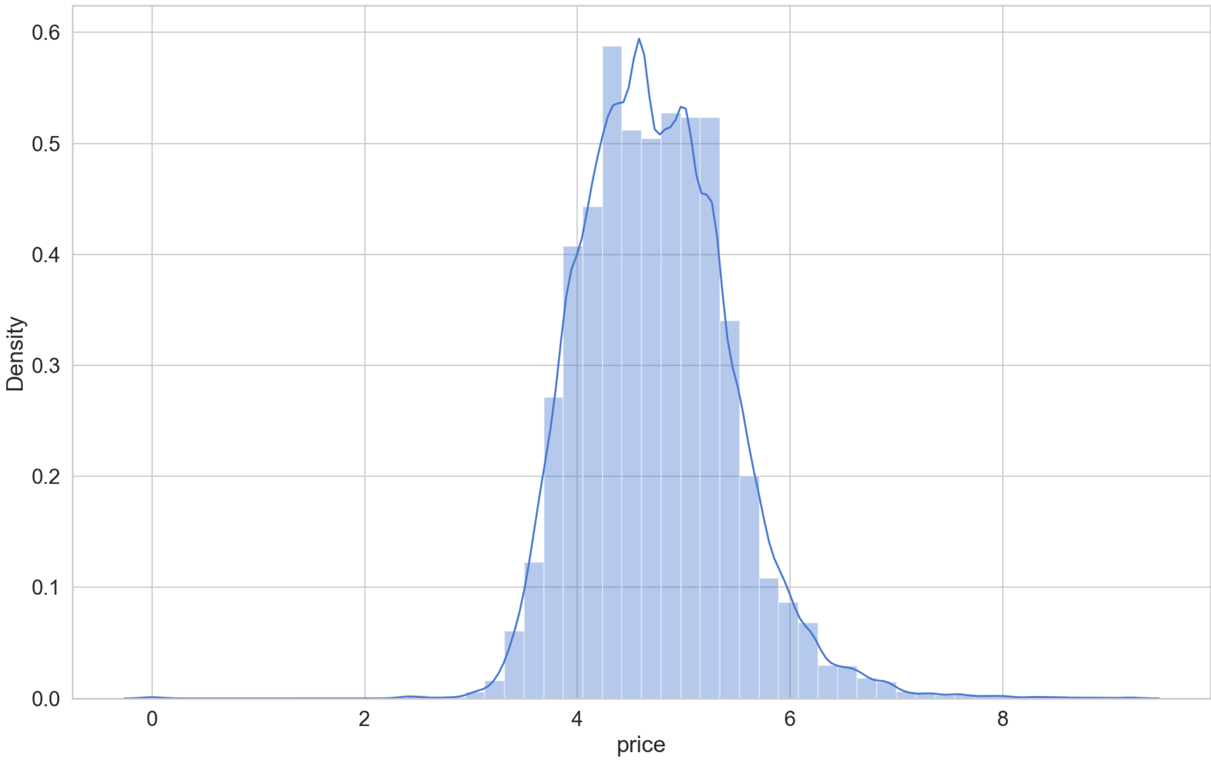
In [6]:
```
y_train.columns
```

Out[6]:
```
Index(['id', 'price'], dtype='object')
```

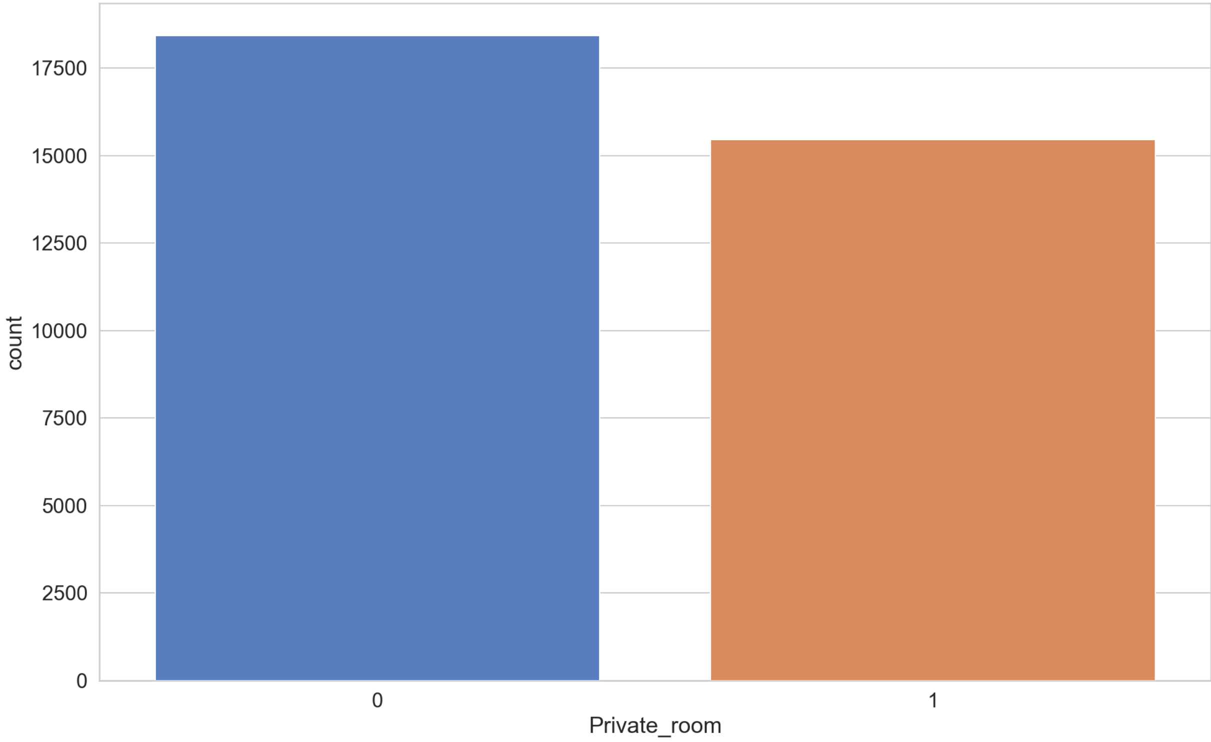
In [7]:
```
sns.distplot(y_train.price);
```



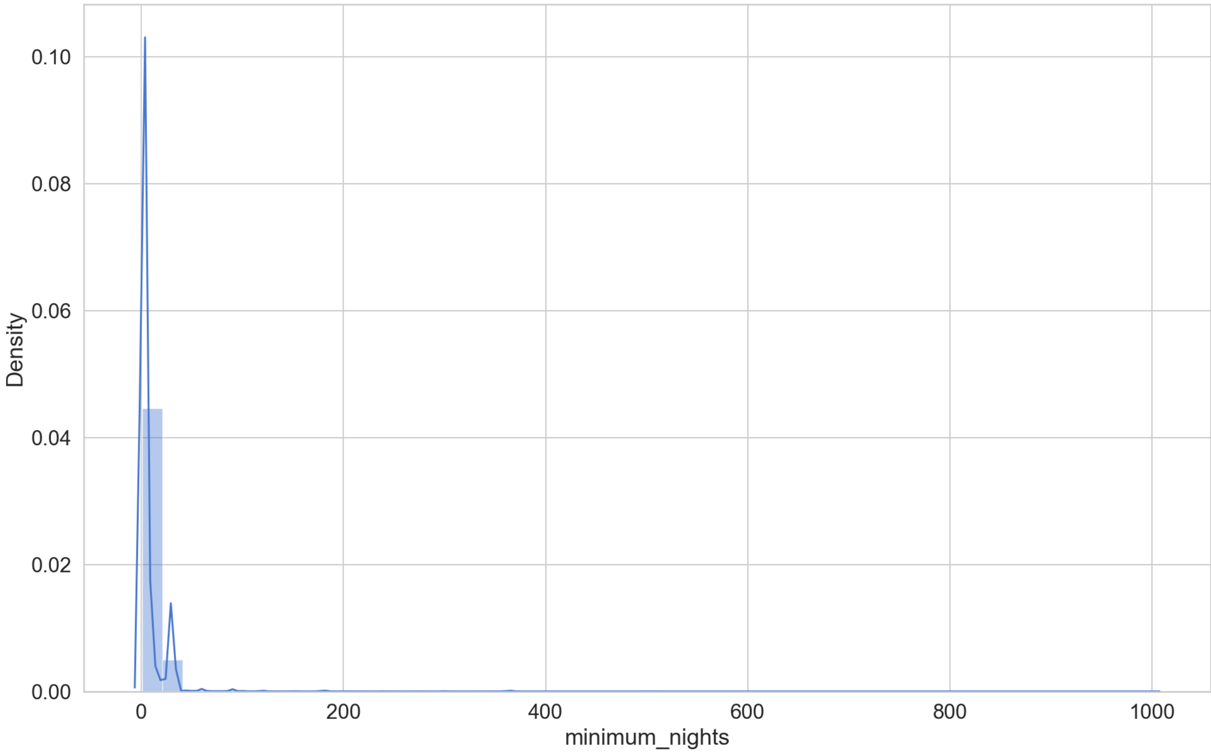
In [8]:
```
sns.distplot(np.log1p(y_train.price));
```



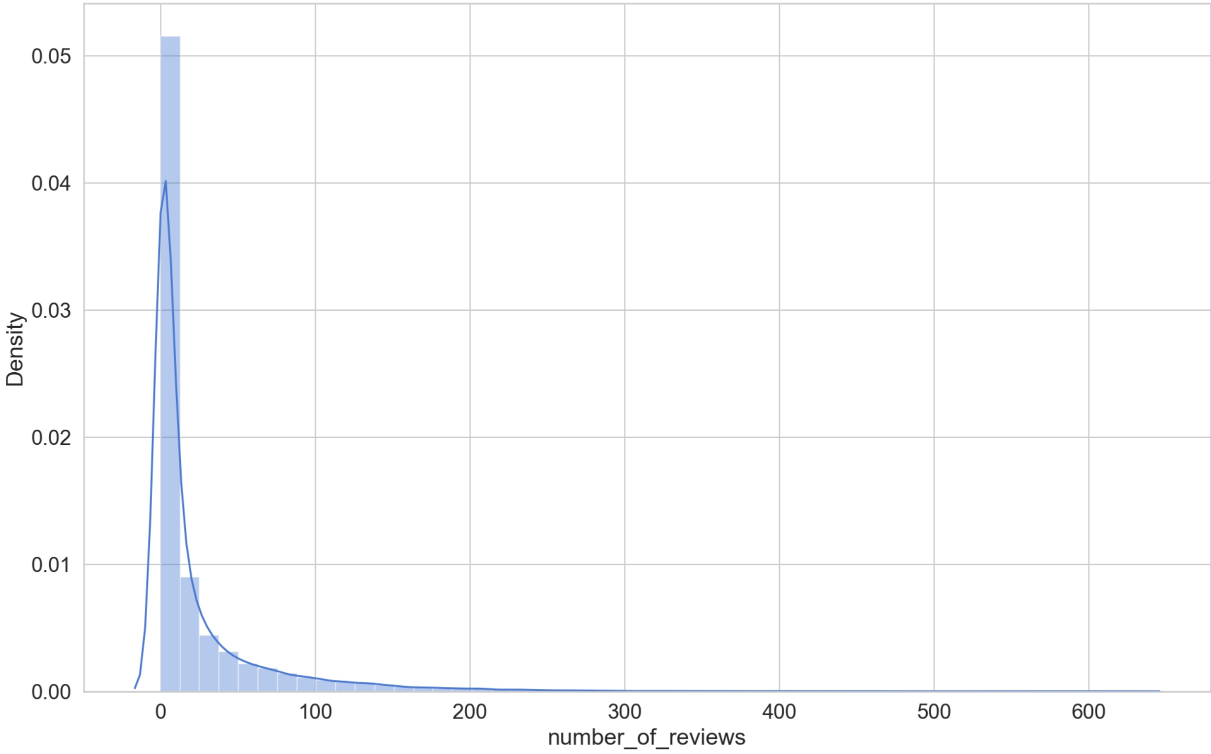
In [9]:
```
sns.countplot(x='Private_room', data=X_train);
```



In [10]:
```
sns.distplot(X_train.minimum_nights);
```



In [11]:
```
sns.distplot(X_train.number_of_reviews);
```



In [12]:

```
corr_matrix = X_train.corr()
corr_matrix_y = y_train.corr()
```

In [13]:

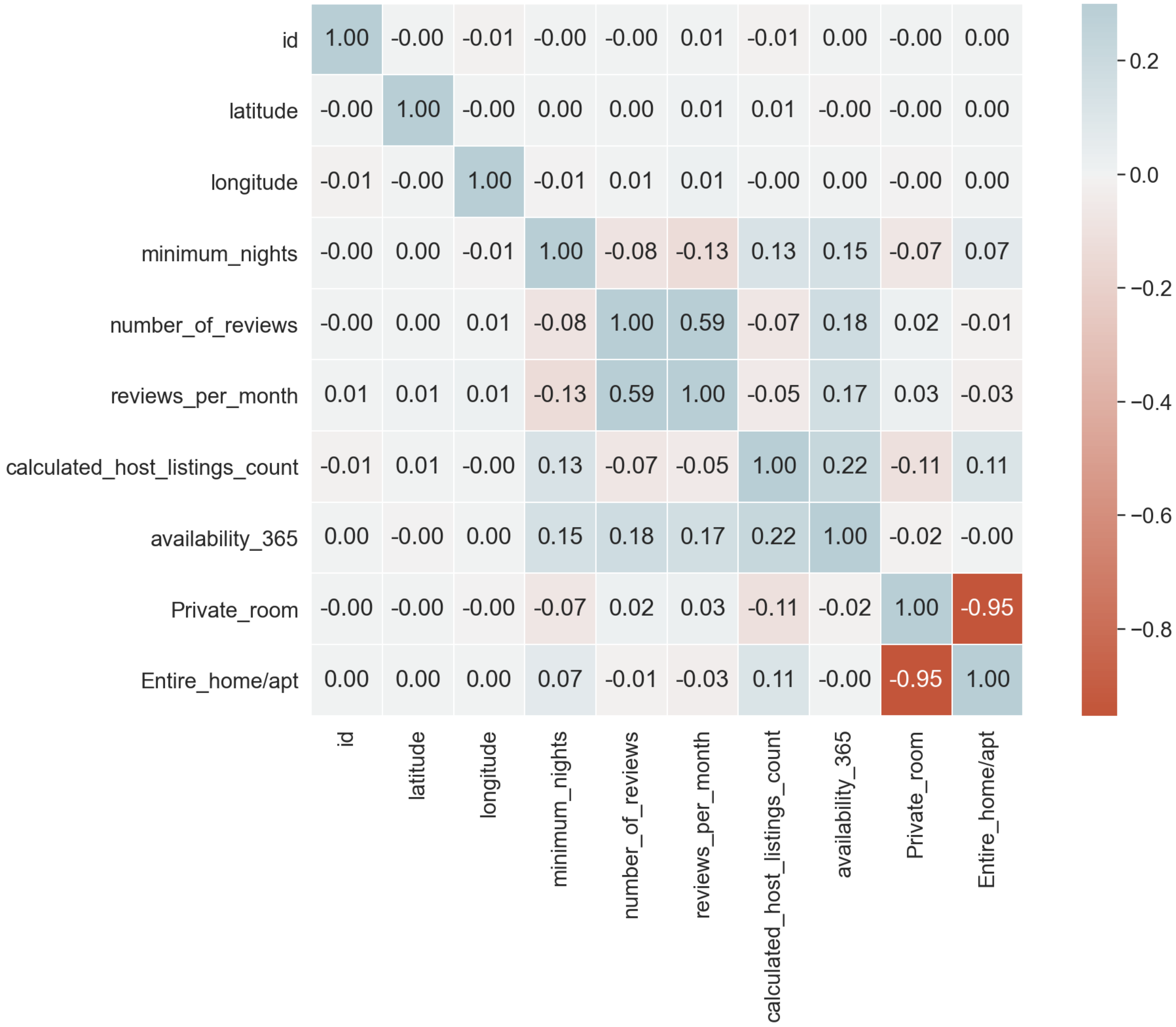
```
price_corr = corr_matrix_y['price']
price_corr.iloc[price_corr.abs().argsort()]
```

Out[13]:

```
id      -0.008333
price    1.000000
Name: price, dtype: float64
```

In [14]:

```
palette = sns.diverging_palette(20, 220, n=256)
sns.heatmap(corr_matrix, annot=True, fmt=".2f", cmap=palette, vmax=.3, center
            square=True, linewidths=.5);
```



Preprocessing

Missing data?

In [15]:
```
missing = X_train.isnull().sum()
missing[missing > 0].sort_values(ascending=False)
```

Out[15]: `Series([], dtype: int64)`

In [16]:
```
missing_y = y_train.isnull().sum()
missing_y[missing_y > 0].sort_values(ascending=False)
```

Out[16]: `Series([], dtype: int64)`

Remove unused columns!

In [17]:
```
X_train = X_train.drop('id', axis=1)
X_test = X_test.drop('id', axis=1)
y_train = y_train.drop('id', axis=1)
```

In [18]:
```
missing = X_train.isnull().sum()
missing[missing > 0].sort_values(ascending=False)
```

Out[18]: `Series([], dtype: int64)`

In [19]:
```
X_train.columns
```

Out[19]:
```
Index(['latitude', 'longitude', 'minimum_nights', 'number_of_reviews',
       'reviews_per_month', 'calculated_host_listings_count',
       'availability_365', 'Private_room', 'Entire_home/apt'],
      dtype='object')
```

In [20]:
```
X_train.head()
```

Out[20]:

	latitude	longitude	minimum_nights	number_of_reviews	reviews_per_month	calculated_hc
0	40.71239	-73.95271	4	2	0.19	
1	40696.00000	-73.91303	4	17	0.66	
2	40.62707	-74.02817	3	1	0.04	
3	40.77910	-73.98565	1	4	0.08	
4	40.75777	-73.93509	1	0	0.00	

Predict log1p

In [21]:
```
X = X_train
y = np.log1p(y_train.price.values)
```

Feature scaling

In [22]:
```
from sklearn.preprocessing import MinMaxScaler, OneHotEncoder
from sklearn.compose import make_column_transformer


transformer = make_column_transformer(
    (MinMaxScaler(), X_train.columns))
```

In [23]:
```
transformer.fit(X)
```

Out[23]:
```
ColumnTransformer(transformers=[('minmaxscaler', MinMaxScaler(),
                                 Index(['latitude', 'longitude', 'minimum_nig
hts', 'number_of_reviews',
       'reviews_per_month', 'calculated_host_listings_count',
       'availability_365', 'Private_room', 'Entire_home/apt'],
      dtype='object'))])
```

In [24]:
```
# scaling
X = transformer.transform(X)
```

Split the training and test data

In [25]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, ranc
```

In [26]:
```
X_train.shape
```

Out[26]:
```
(27107, 9)
```

Neural Network Model (3-layers)

In [27]:
```
def plot_mse(history):
  hist = pd.DataFrame(history.history)
```

```
  hist['epoch'] = history.epoch

  plt.figure()
  plt.xlabel('Epoch')
  plt.ylabel('MSE')
  plt.plot(hist['epoch'], hist['mse'],
           label='Train MSE')
  plt.plot(hist['epoch'], hist['val_mse'],
           label = 'Val MSE')
  plt.legend()
  plt.show()
```

In [28]:

```
model1 = keras.Sequential()
model1.add(keras.layers.Dense(units=32, activation="relu", input_shape=[X_tra
model1.add(keras.layers.Dense(units=64, activation="relu"))
model1.add(keras.layers.Dense(units=128, activation='relu'))

model1.add(keras.layers.Dense(1, activation="linear"))

model1.compile(
    optimizer=keras.optimizers.Adam(0.0001),
    loss = 'mse',
    metrics = ['mse'])

BATCH_SIZE = 32

early_stop = keras.callbacks.EarlyStopping(
  monitor='val_mse',
  mode="min",
  patience=10
)

history = model1.fit(
  x=X_train,
  y=y_train,
  shuffle=True,
  epochs=100,
  validation_split=0.2,
  batch_size=BATCH_SIZE
)

plot_mse(history)
```

```
Epoch 1/100
678/678 [==============================] - 1s 2ms/step - loss: 4.7365 - mse:
4.7365 - val_loss: 0.3555 - val_mse: 0.3555
Epoch 2/100
678/678 [==============================] - 3s 4ms/step - loss: 0.3431 - mse:
0.3431 - val_loss: 0.3226 - val_mse: 0.3226
Epoch 3/100
678/678 [==============================] - 2s 3ms/step - loss: 0.3165 - mse:
0.3165 - val_loss: 0.3055 - val_mse: 0.3055
Epoch 4/100
678/678 [==============================] - 3s 4ms/step - loss: 0.3030 - mse:
0.3030 - val_loss: 0.2958 - val_mse: 0.2958
Epoch 5/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2980 - mse:
0.2980 - val_loss: 0.2933 - val_mse: 0.2933
Epoch 6/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2960 - mse:
0.2960 - val_loss: 0.2914 - val_mse: 0.2914
Epoch 7/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2947 - mse:
0.2947 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 8/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2934 - mse:
```

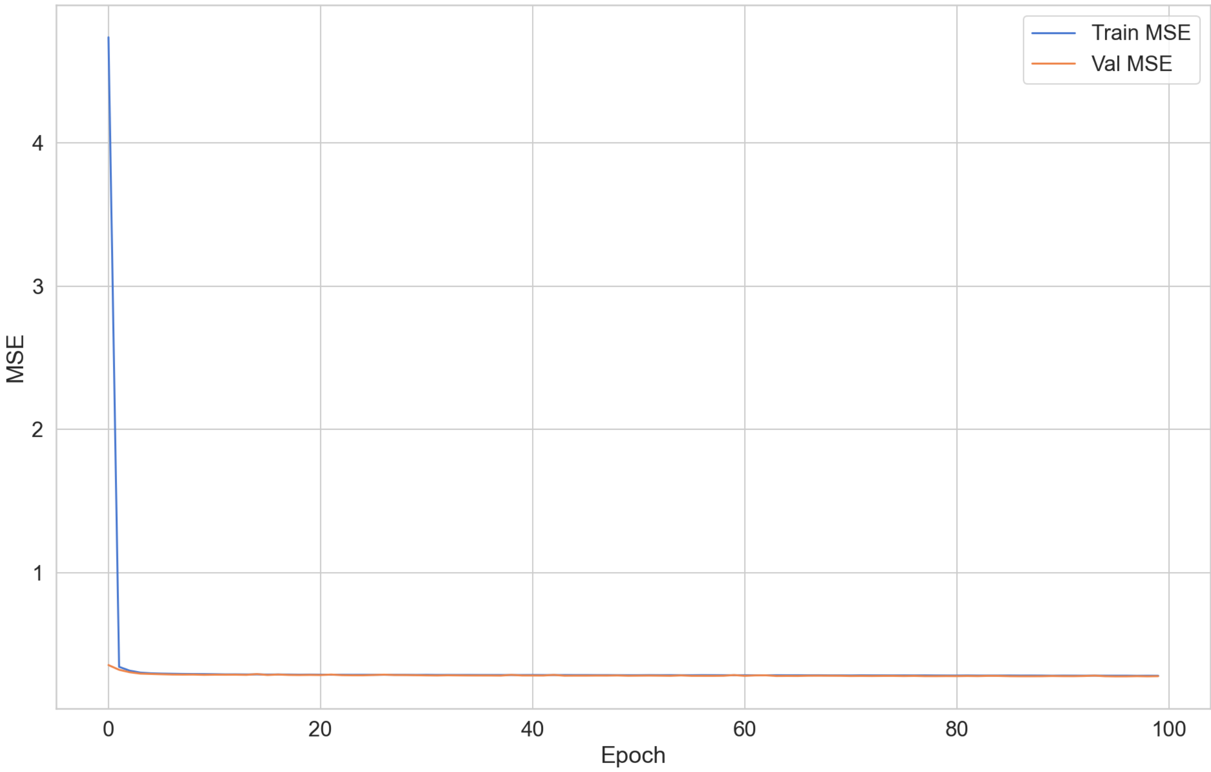
```
0.2934 - val_loss: 0.2890 - val_mse: 0.2890
Epoch 9/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2930 - mse:
0.2930 - val_loss: 0.2893 - val_mse: 0.2893
Epoch 10/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2926 - mse:
0.2926 - val_loss: 0.2875 - val_mse: 0.2875
Epoch 11/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2918 - mse:
0.2918 - val_loss: 0.2885 - val_mse: 0.2885
Epoch 12/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2907 - mse:
0.2907 - val_loss: 0.2882 - val_mse: 0.2882
Epoch 13/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2908 - mse:
0.2908 - val_loss: 0.2884 - val_mse: 0.2884
Epoch 14/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2902 - mse:
0.2902 - val_loss: 0.2872 - val_mse: 0.2872
Epoch 15/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2905 - mse:
0.2905 - val_loss: 0.2926 - val_mse: 0.2926
Epoch 16/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 17/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2900 - mse:
0.2900 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 18/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 19/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2887 - mse:
0.2887 - val_loss: 0.2858 - val_mse: 0.2858
Epoch 20/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2892 - mse:
0.2892 - val_loss: 0.2868 - val_mse: 0.2868
Epoch 21/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2887 - mse:
0.2887 - val_loss: 0.2858 - val_mse: 0.2858
Epoch 22/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2895 - val_mse: 0.2895
Epoch 23/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2852 - val_mse: 0.2852
Epoch 24/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2879 - mse:
0.2879 - val_loss: 0.2841 - val_mse: 0.2841
Epoch 25/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2880 - mse:
0.2880 - val_loss: 0.2839 - val_mse: 0.2839
Epoch 26/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2862 - val_mse: 0.2862
Epoch 27/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2881 - mse:
0.2881 - val_loss: 0.2888 - val_mse: 0.2888
Epoch 28/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 29/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2877 - mse:
0.2877 - val_loss: 0.2856 - val_mse: 0.2856
Epoch 30/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2872 - mse:
0.2872 - val_loss: 0.2846 - val_mse: 0.2846
Epoch 31/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2877 - mse:
```

```
0.2877 - val_loss: 0.2835 - val_mse: 0.2835
Epoch 32/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2869 - mse:
0.2869 - val_loss: 0.2827 - val_mse: 0.2827
Epoch 33/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2871 - mse:
0.2871 - val_loss: 0.2842 - val_mse: 0.2842
Epoch 34/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2868 - mse:
0.2868 - val_loss: 0.2834 - val_mse: 0.2834
Epoch 35/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2868 - mse:
0.2868 - val_loss: 0.2828 - val_mse: 0.2828
Epoch 36/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2866 - mse:
0.2866 - val_loss: 0.2826 - val_mse: 0.2826
Epoch 37/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2865 - mse:
0.2865 - val_loss: 0.2825 - val_mse: 0.2825
Epoch 38/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2863 - mse:
0.2863 - val_loss: 0.2818 - val_mse: 0.2818
Epoch 39/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2862 - mse:
0.2862 - val_loss: 0.2871 - val_mse: 0.2871
Epoch 40/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2862 - mse:
0.2862 - val_loss: 0.2827 - val_mse: 0.2827
Epoch 41/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2864 - mse:
0.2864 - val_loss: 0.2826 - val_mse: 0.2826
Epoch 42/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2861 - mse:
0.2861 - val_loss: 0.2823 - val_mse: 0.2823
Epoch 43/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2860 - mse:
0.2860 - val_loss: 0.2869 - val_mse: 0.2869
Epoch 44/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2861 - mse:
0.2861 - val_loss: 0.2812 - val_mse: 0.2812
Epoch 45/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2859 - mse:
0.2859 - val_loss: 0.2815 - val_mse: 0.2815
Epoch 46/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2859 - mse:
0.2859 - val_loss: 0.2815 - val_mse: 0.2815
Epoch 47/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2856 - mse:
0.2856 - val_loss: 0.2820 - val_mse: 0.2820
Epoch 48/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2856 - mse:
0.2856 - val_loss: 0.2819 - val_mse: 0.2819
Epoch 49/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2853 - mse:
0.2853 - val_loss: 0.2829 - val_mse: 0.2829
Epoch 50/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2849 - mse:
0.2849 - val_loss: 0.2807 - val_mse: 0.2807
Epoch 51/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2849 - mse:
0.2849 - val_loss: 0.2814 - val_mse: 0.2814
Epoch 52/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2856 - mse:
0.2856 - val_loss: 0.2819 - val_mse: 0.2819
Epoch 53/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2852 - mse:
0.2852 - val_loss: 0.2812 - val_mse: 0.2812
Epoch 54/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2853 - mse:
```

```
0.2853 - val_loss: 0.2803 - val_mse: 0.2803
Epoch 55/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2849 - mse:
0.2849 - val_loss: 0.2831 - val_mse: 0.2831
Epoch 56/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2847 - mse:
0.2847 - val_loss: 0.2801 - val_mse: 0.2801
Epoch 57/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2854 - mse:
0.2854 - val_loss: 0.2801 - val_mse: 0.2801
Epoch 58/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2851 - mse:
0.2851 - val_loss: 0.2800 - val_mse: 0.2800
Epoch 59/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2848 - mse:
0.2848 - val_loss: 0.2806 - val_mse: 0.2806
Epoch 60/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2848 - mse:
0.2848 - val_loss: 0.2857 - val_mse: 0.2857
Epoch 61/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2844 - mse:
0.2844 - val_loss: 0.2801 - val_mse: 0.2801
Epoch 62/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2843 - mse:
0.2843 - val_loss: 0.2834 - val_mse: 0.2834
Epoch 63/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2841 - mse:
0.2841 - val_loss: 0.2839 - val_mse: 0.2839
Epoch 64/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2846 - mse:
0.2846 - val_loss: 0.2792 - val_mse: 0.2792
Epoch 65/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2844 - mse:
0.2844 - val_loss: 0.2797 - val_mse: 0.2797
Epoch 66/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2844 - mse:
0.2844 - val_loss: 0.2793 - val_mse: 0.2793
Epoch 67/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2842 - mse:
0.2842 - val_loss: 0.2809 - val_mse: 0.2809
Epoch 68/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2843 - mse:
0.2843 - val_loss: 0.2810 - val_mse: 0.2810
Epoch 69/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2837 - mse:
0.2837 - val_loss: 0.2807 - val_mse: 0.2807
Epoch 70/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2836 - mse:
0.2836 - val_loss: 0.2805 - val_mse: 0.2805
Epoch 71/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2833 - mse:
0.2833 - val_loss: 0.2791 - val_mse: 0.2791
Epoch 72/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2841 - mse:
0.2841 - val_loss: 0.2796 - val_mse: 0.2796
Epoch 73/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2837 - mse:
0.2837 - val_loss: 0.2791 - val_mse: 0.2791
Epoch 74/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2836 - mse:
0.2836 - val_loss: 0.2796 - val_mse: 0.2796
Epoch 75/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2834 - mse:
0.2834 - val_loss: 0.2798 - val_mse: 0.2798
Epoch 76/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2836 - mse:
0.2836 - val_loss: 0.2788 - val_mse: 0.2788
Epoch 77/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2833 - mse:
```

```
0.2833 - val_loss: 0.2797 - val_mse: 0.2797
Epoch 78/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2836 - mse:
0.2836 - val_loss: 0.2781 - val_mse: 0.2781
Epoch 79/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2830 - mse:
0.2830 - val_loss: 0.2781 - val_mse: 0.2781
Epoch 80/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2828 - mse:
0.2828 - val_loss: 0.2786 - val_mse: 0.2786
Epoch 81/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2824 - mse:
0.2824 - val_loss: 0.2783 - val_mse: 0.2783
Epoch 82/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2831 - mse:
0.2831 - val_loss: 0.2792 - val_mse: 0.2792
Epoch 83/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2824 - mse:
0.2824 - val_loss: 0.2784 - val_mse: 0.2784
Epoch 84/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2824 - mse:
0.2824 - val_loss: 0.2801 - val_mse: 0.2801
Epoch 85/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2826 - mse:
0.2826 - val_loss: 0.2795 - val_mse: 0.2795
Epoch 86/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2828 - mse:
0.2828 - val_loss: 0.2778 - val_mse: 0.2778
Epoch 87/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2824 - mse:
0.2824 - val_loss: 0.2774 - val_mse: 0.2774
Epoch 88/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2825 - mse:
0.2825 - val_loss: 0.2774 - val_mse: 0.2774
Epoch 89/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2822 - mse:
0.2822 - val_loss: 0.2776 - val_mse: 0.2776
Epoch 90/100
678/678 [==============================] - 2s 4ms/step - loss: 0.2815 - mse:
0.2815 - val_loss: 0.2790 - val_mse: 0.2790
Epoch 91/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2820 - mse:
0.2820 - val_loss: 0.2781 - val_mse: 0.2781
Epoch 92/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2818 - mse:
0.2818 - val_loss: 0.2779 - val_mse: 0.2779
Epoch 93/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2815 - mse:
0.2815 - val_loss: 0.2790 - val_mse: 0.2790
Epoch 94/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2818 - mse:
0.2818 - val_loss: 0.2817 - val_mse: 0.2817
Epoch 95/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2815 - mse:
0.2815 - val_loss: 0.2776 - val_mse: 0.2776
Epoch 96/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2814 - mse:
0.2814 - val_loss: 0.2765 - val_mse: 0.2765
Epoch 97/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2815 - mse:
0.2815 - val_loss: 0.2767 - val_mse: 0.2767
Epoch 98/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2808 - mse:
0.2808 - val_loss: 0.2780 - val_mse: 0.2780
Epoch 99/100
678/678 [==============================] - 2s 3ms/step - loss: 0.2811 - mse:
0.2811 - val_loss: 0.2768 - val_mse: 0.2768
Epoch 100/100
```

```
678/678 [==============================] - 2s 3ms/step - loss: 0.2808 - mse:
0.2808 - val_loss: 0.2779 - val_mse: 0.2779
```



Four-layer neural network and more epochs model

In [29]:

```
model2 = keras.Sequential()
model2.add(keras.layers.Dense(units=64, activation="relu", input_shape=[X_tra
model2.add(keras.layers.Dense(units=128, activation="sigmoid"))
model2.add(keras.layers.Dense(units=256, activation="sigmoid"))
model2.add(keras.layers.Dense(units=512, activation="relu"))
model2.add(keras.layers.Dense(1, activation='linear'))

model2.compile(
    optimizer=keras.optimizers.Adam(0.0001),
    loss = 'mse',
    metrics = ['mse'])

BATCH_SIZE = 64

early_stop = keras.callbacks.EarlyStopping(
  monitor='val_mse',
  mode="min",
  patience=10
)

history = model2.fit(
  x=X_train,
  y=y_train,
  shuffle=True,
  epochs=150,
  validation_split=0.2,
  batch_size=BATCH_SIZE
)

plot_mse(history)
```

```
50
339/339 [==============================] - 2s 6ms/step - loss: 0.4299 - mse:
0.4299 - val_loss: 0.3759 - val_mse: 0.3759
Epoch 3/150
```

```
339/339 [==============================] - 3s 8ms/step - loss: 0.3298 - mse:
0.3298 - val_loss: 0.3110 - val_mse: 0.3110
Epoch 4/150
339/339 [==============================] - 3s 8ms/step - loss: 0.3101 - mse:
0.3101 - val_loss: 0.3053 - val_mse: 0.3053
Epoch 5/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3070 - mse:
0.3070 - val_loss: 0.3026 - val_mse: 0.3026
Epoch 6/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3058 - mse:
0.3058 - val_loss: 0.3049 - val_mse: 0.3049
Epoch 7/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3040 - mse:
0.3040 - val_loss: 0.2987 - val_mse: 0.2987
Epoch 8/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3018 - mse:
0.3018 - val_loss: 0.2972 - val_mse: 0.2972
Epoch 9/150
339/339 [==============================] - 3s 8ms/step - loss: 0.3007 - mse:
0.3007 - val_loss: 0.2965 - val_mse: 0.2965
Epoch 10/150
339/339 [==============================] - 3s 8ms/step - loss: 0.2998 - mse:
0.2998 - val_loss: 0.2947 - val_mse: 0.2947
Epoch 11/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2978 - mse:
0.2978 - val_loss: 0.2953 - val_mse: 0.2953
Epoch 12/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2960 - mse:
0.2960 - val_loss: 0.2935 - val_mse: 0.2935
Epoch 13/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2967 - mse:
0.2967 - val_loss: 0.2946 - val_mse: 0.2946
Epoch 14/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.2982 - val_mse: 0.2982
Epoch 15/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2968 - mse:
0.2968 - val_loss: 0.2984 - val_mse: 0.2984
Epoch 16/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2942 - mse:
0.2942 - val_loss: 0.2908 - val_mse: 0.2908
Epoch 17/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2963 - mse:
0.2963 - val_loss: 0.2970 - val_mse: 0.2970
Epoch 18/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2961 - mse:
0.2961 - val_loss: 0.2925 - val_mse: 0.2925
Epoch 19/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2935 - mse:
0.2935 - val_loss: 0.2902 - val_mse: 0.2902
Epoch 20/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.2972 - val_mse: 0.2972
Epoch 21/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2947 - mse:
0.2947 - val_loss: 0.2907 - val_mse: 0.2907
Epoch 22/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2932 - mse:
0.2932 - val_loss: 0.2932 - val_mse: 0.2932
Epoch 23/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2942 - mse:
0.2942 - val_loss: 0.2970 - val_mse: 0.2970
Epoch 24/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2929 - mse:
0.2929 - val_loss: 0.2902 - val_mse: 0.2902
Epoch 25/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2933 - mse:
0.2933 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 26/150
```

```
339/339 [==============================] - 2s 7ms/step - loss: 0.2933 - mse:
0.2933 - val_loss: 0.2922 - val_mse: 0.2922
Epoch 27/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2946 - mse:
0.2946 - val_loss: 0.3020 - val_mse: 0.3020
Epoch 28/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2938 - mse:
0.2938 - val_loss: 0.2897 - val_mse: 0.2897
Epoch 29/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2936 - mse:
0.2936 - val_loss: 0.2923 - val_mse: 0.2923
Epoch 30/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2931 - mse:
0.2931 - val_loss: 0.2944 - val_mse: 0.2944
Epoch 31/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2942 - mse:
0.2942 - val_loss: 0.2920 - val_mse: 0.2920
Epoch 32/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2931 - mse:
0.2931 - val_loss: 0.2890 - val_mse: 0.2890
Epoch 33/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2933 - mse:
0.2933 - val_loss: 0.2886 - val_mse: 0.2886
Epoch 34/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2925 - mse:
0.2925 - val_loss: 0.2912 - val_mse: 0.2912
Epoch 35/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2929 - mse:
0.2929 - val_loss: 0.2900 - val_mse: 0.2900
Epoch 36/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2921 - mse:
0.2921 - val_loss: 0.2885 - val_mse: 0.2885
Epoch 37/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2922 - mse:
0.2922 - val_loss: 0.2885 - val_mse: 0.2885
Epoch 38/150
339/339 [==============================] - 3s 8ms/step - loss: 0.2921 - mse:
0.2921 - val_loss: 0.2901 - val_mse: 0.2901
Epoch 39/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2923 - mse:
0.2923 - val_loss: 0.2971 - val_mse: 0.2971
Epoch 40/150
339/339 [==============================] - 3s 7ms/step - loss: 0.2921 - mse:
0.2921 - val_loss: 0.2883 - val_mse: 0.2883
Epoch 41/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2938 - mse:
0.2938 - val_loss: 0.2883 - val_mse: 0.2883
Epoch 42/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2922 - mse:
0.2922 - val_loss: 0.2922 - val_mse: 0.2922
Epoch 43/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2925 - mse:
0.2925 - val_loss: 0.2977 - val_mse: 0.2977
Epoch 44/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2928 - mse:
0.2928 - val_loss: 0.2894 - val_mse: 0.2894
Epoch 45/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2917 - mse:
0.2917 - val_loss: 0.2878 - val_mse: 0.2878
Epoch 46/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2919 - mse:
0.2919 - val_loss: 0.2878 - val_mse: 0.2878
Epoch 47/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2923 - mse:
0.2923 - val_loss: 0.2894 - val_mse: 0.2894
Epoch 48/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2920 - mse:
0.2920 - val_loss: 0.2879 - val_mse: 0.2879
Epoch 49/150
```

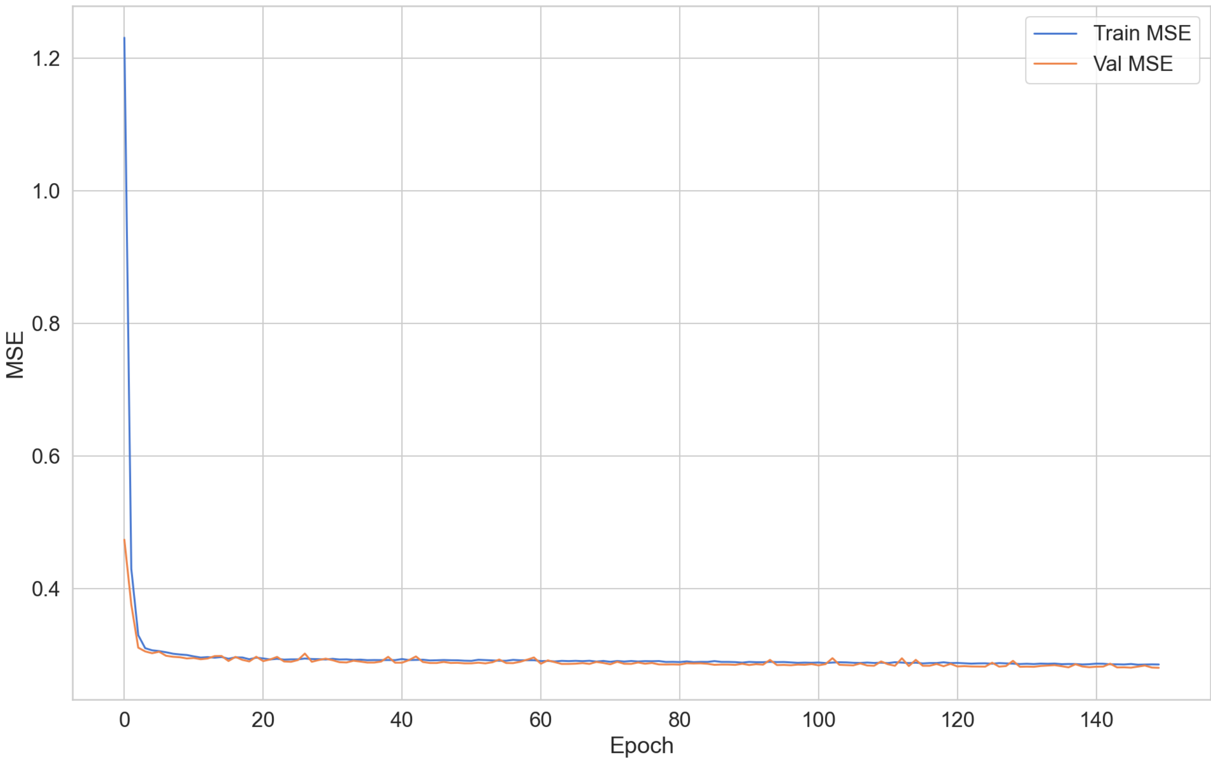
```
339/339 [==============================] - 2s 7ms/step - loss: 0.2919 - mse: 0.2919 - val_loss: 0.2881 - val_mse: 0.2881
Epoch 50/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2913 - mse: 0.2913 - val_loss: 0.2873 - val_mse: 0.2873
Epoch 51/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2911 - mse: 0.2911 - val_loss: 0.2873 - val_mse: 0.2873
Epoch 52/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2927 - mse: 0.2927 - val_loss: 0.2883 - val_mse: 0.2883
Epoch 53/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2922 - mse: 0.2922 - val_loss: 0.2873 - val_mse: 0.2873
Epoch 54/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2917 - mse: 0.2917 - val_loss: 0.2889 - val_mse: 0.2889
Epoch 55/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2912 - mse: 0.2912 - val_loss: 0.2930 - val_mse: 0.2930
Epoch 56/150
339/339 [==============================] - 3s 7ms/step - loss: 0.2912 - mse: 0.2912 - val_loss: 0.2878 - val_mse: 0.2878
Epoch 57/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2925 - mse: 0.2925 - val_loss: 0.2876 - val_mse: 0.2876
Epoch 58/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2919 - mse: 0.2919 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 59/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2920 - mse: 0.2920 - val_loss: 0.2927 - val_mse: 0.2927
Epoch 60/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2920 - mse: 0.2920 - val_loss: 0.2961 - val_mse: 0.2961
Epoch 61/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2907 - mse: 0.2907 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 62/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2910 - mse: 0.2910 - val_loss: 0.2918 - val_mse: 0.2918
Epoch 63/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2902 - mse: 0.2902 - val_loss: 0.2890 - val_mse: 0.2890
Epoch 64/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2911 - mse: 0.2911 - val_loss: 0.2864 - val_mse: 0.2864
Epoch 65/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2907 - mse: 0.2907 - val_loss: 0.2865 - val_mse: 0.2865
Epoch 66/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2911 - mse: 0.2911 - val_loss: 0.2868 - val_mse: 0.2868
Epoch 67/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2907 - mse: 0.2907 - val_loss: 0.2877 - val_mse: 0.2877
Epoch 68/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2912 - mse: 0.2912 - val_loss: 0.2865 - val_mse: 0.2865
Epoch 69/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2900 - mse: 0.2900 - val_loss: 0.2894 - val_mse: 0.2894
Epoch 70/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2910 - mse: 0.2910 - val_loss: 0.2878 - val_mse: 0.2878
Epoch 71/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2896 - mse: 0.2896 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 72/150
```

```
339/339 [==============================] - 2s 7ms/step - loss: 0.2909 - mse:
0.2909 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 73/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2900 - mse:
0.2900 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 74/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2909 - mse:
0.2909 - val_loss: 0.2865 - val_mse: 0.2865
Epoch 75/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2901 - mse:
0.2901 - val_loss: 0.2886 - val_mse: 0.2886
Epoch 76/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2907 - mse:
0.2907 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 77/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2905 - mse:
0.2905 - val_loss: 0.2879 - val_mse: 0.2879
Epoch 78/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2908 - mse:
0.2908 - val_loss: 0.2857 - val_mse: 0.2857
Epoch 79/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2894 - mse:
0.2894 - val_loss: 0.2856 - val_mse: 0.2856
Epoch 80/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.2857 - val_mse: 0.2857
Epoch 81/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2892 - mse:
0.2892 - val_loss: 0.2854 - val_mse: 0.2854
Epoch 82/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2902 - mse:
0.2902 - val_loss: 0.2874 - val_mse: 0.2874
Epoch 83/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2891 - mse:
0.2891 - val_loss: 0.2872 - val_mse: 0.2872
Epoch 84/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.2874 - val_mse: 0.2874
Epoch 85/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2894 - mse:
0.2894 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 86/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2907 - mse:
0.2907 - val_loss: 0.2851 - val_mse: 0.2851
Epoch 87/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.2855 - val_mse: 0.2855
Epoch 88/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2894 - mse:
0.2894 - val_loss: 0.2854 - val_mse: 0.2854
Epoch 89/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2891 - mse:
0.2891 - val_loss: 0.2850 - val_mse: 0.2850
Epoch 90/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2866 - val_mse: 0.2866
Epoch 91/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2894 - mse:
0.2894 - val_loss: 0.2848 - val_mse: 0.2848
Epoch 92/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2860 - val_mse: 0.2860
Epoch 93/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2853 - val_mse: 0.2853
Epoch 94/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2896 - mse:
0.2896 - val_loss: 0.2925 - val_mse: 0.2925
Epoch 95/150
```

```
339/339 [==============================] - 2s 7ms/step - loss: 0.2891 - mse:
0.2891 - val_loss: 0.2847 - val_mse: 0.2847
Epoch 96/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2893 - mse:
0.2893 - val_loss: 0.2849 - val_mse: 0.2849
Epoch 97/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2887 - mse:
0.2887 - val_loss: 0.2844 - val_mse: 0.2844
Epoch 98/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2881 - mse:
0.2881 - val_loss: 0.2854 - val_mse: 0.2854
Epoch 99/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2884 - mse:
0.2884 - val_loss: 0.2851 - val_mse: 0.2851
Epoch 100/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2882 - mse:
0.2882 - val_loss: 0.2862 - val_mse: 0.2862
Epoch 101/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2885 - mse:
0.2885 - val_loss: 0.2843 - val_mse: 0.2843
Epoch 102/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2862 - val_mse: 0.2862
Epoch 103/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2885 - mse:
0.2885 - val_loss: 0.2951 - val_mse: 0.2951
Epoch 104/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2889 - mse:
0.2889 - val_loss: 0.2851 - val_mse: 0.2851
Epoch 105/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2887 - mse:
0.2887 - val_loss: 0.2847 - val_mse: 0.2847
Epoch 106/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2881 - mse:
0.2881 - val_loss: 0.2842 - val_mse: 0.2842
Epoch 107/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2879 - mse:
0.2879 - val_loss: 0.2872 - val_mse: 0.2872
Epoch 108/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2885 - mse:
0.2885 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 109/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2879 - mse:
0.2879 - val_loss: 0.2837 - val_mse: 0.2837
Epoch 110/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2902 - val_mse: 0.2902
Epoch 111/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2877 - mse:
0.2877 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 112/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2836 - val_mse: 0.2836
Epoch 113/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2884 - mse:
0.2884 - val_loss: 0.2949 - val_mse: 0.2949
Epoch 114/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2877 - mse:
0.2877 - val_loss: 0.2832 - val_mse: 0.2832
Epoch 115/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2926 - val_mse: 0.2926
Epoch 116/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2872 - mse:
0.2872 - val_loss: 0.2836 - val_mse: 0.2836
Epoch 117/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2837 - val_mse: 0.2837
Epoch 118/150
```

```
339/339 [==============================] - 2s 6ms/step - loss: 0.2878 - mse: 0.2878 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 119/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2889 - mse: 0.2889 - val_loss: 0.2829 - val_mse: 0.2829
Epoch 120/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2877 - mse: 0.2877 - val_loss: 0.2865 - val_mse: 0.2865
Epoch 121/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2879 - mse: 0.2879 - val_loss: 0.2827 - val_mse: 0.2827
Epoch 122/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2874 - mse: 0.2874 - val_loss: 0.2831 - val_mse: 0.2831
Epoch 123/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2869 - mse: 0.2869 - val_loss: 0.2826 - val_mse: 0.2826
Epoch 124/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2873 - mse: 0.2873 - val_loss: 0.2825 - val_mse: 0.2825
Epoch 125/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2874 - mse: 0.2874 - val_loss: 0.2824 - val_mse: 0.2824
Epoch 126/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2868 - mse: 0.2868 - val_loss: 0.2882 - val_mse: 0.2882
Epoch 127/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2877 - mse: 0.2877 - val_loss: 0.2824 - val_mse: 0.2824
Epoch 128/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2873 - mse: 0.2873 - val_loss: 0.2833 - val_mse: 0.2833
Epoch 129/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2868 - mse: 0.2868 - val_loss: 0.2911 - val_mse: 0.2911
Epoch 130/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2863 - mse: 0.2863 - val_loss: 0.2821 - val_mse: 0.2821
Epoch 131/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2867 - mse: 0.2867 - val_loss: 0.2823 - val_mse: 0.2823
Epoch 132/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2862 - mse: 0.2862 - val_loss: 0.2821 - val_mse: 0.2821
Epoch 133/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2869 - mse: 0.2869 - val_loss: 0.2834 - val_mse: 0.2834
Epoch 134/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2867 - mse: 0.2867 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 135/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2870 - mse: 0.2870 - val_loss: 0.2846 - val_mse: 0.2846
Epoch 136/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2861 - mse: 0.2861 - val_loss: 0.2830 - val_mse: 0.2830
Epoch 137/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2863 - mse: 0.2863 - val_loss: 0.2813 - val_mse: 0.2813
Epoch 138/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2862 - mse: 0.2862 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 139/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2856 - mse: 0.2856 - val_loss: 0.2826 - val_mse: 0.2826
Epoch 140/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2860 - mse: 0.2860 - val_loss: 0.2815 - val_mse: 0.2815
Epoch 141/150
```

```
339/339 [==============================] - 2s 7ms/step - loss: 0.2868 - mse:
0.2868 - val_loss: 0.2822 - val_mse: 0.2822
Epoch 142/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2867 - mse:
0.2867 - val_loss: 0.2824 - val_mse: 0.2824
Epoch 143/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2859 - mse:
0.2859 - val_loss: 0.2868 - val_mse: 0.2868
Epoch 144/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2858 - mse:
0.2858 - val_loss: 0.2811 - val_mse: 0.2811
Epoch 145/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2856 - mse:
0.2856 - val_loss: 0.2813 - val_mse: 0.2813
Epoch 146/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2863 - mse:
0.2863 - val_loss: 0.2808 - val_mse: 0.2808
Epoch 147/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2852 - mse:
0.2852 - val_loss: 0.2824 - val_mse: 0.2824
Epoch 148/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2854 - mse:
0.2854 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 149/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2857 - mse:
0.2857 - val_loss: 0.2809 - val_mse: 0.2809
Epoch 150/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2856 - mse:
0.2856 - val_loss: 0.2806 - val_mse: 0.2806
```



Neural Network with SDG optimizer

In [30]:

```
model3 = keras.Sequential()
model3.add(keras.layers.Dense(units=64, activation="relu", input_shape=[X_tra
model3.add(keras.layers.Dense(units=128, activation="selu"))
model3.add(keras.layers.Dense(units=256, activation="selu"))
model3.add(keras.layers.Dense(units=512, activation="relu"))
model3.add(keras.layers.Dense(1, activation='linear'))

model3.compile(
    optimizer='SGD',
    loss = 'mse',
```

```
    metrics = ['mse'])

BATCH_SIZE = 64

early_stop = keras.callbacks.EarlyStopping(
  monitor='val_mse',
  mode="min",
  patience=10
)

history = model3.fit(
  x=X_train,
  y=y_train,
  shuffle=True,
  epochs=150,
  validation_split=0.2,
  batch_size=BATCH_SIZE
)

plot_mse(history)
```

```
50
339/339 [==============================] - 2s 7ms/step - loss: 0.3291 - mse:
0.3291 - val_loss: 0.3709 - val_mse: 0.3709
Epoch 3/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3131 - mse:
0.3131 - val_loss: 0.2965 - val_mse: 0.2965
Epoch 4/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3112 - mse:
0.3112 - val_loss: 0.3099 - val_mse: 0.3099
Epoch 5/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3018 - mse:
0.3018 - val_loss: 0.2891 - val_mse: 0.2891
Epoch 6/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3080 - mse:
0.3080 - val_loss: 0.2889 - val_mse: 0.2889
Epoch 7/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3045 - mse:
0.3045 - val_loss: 0.2896 - val_mse: 0.2896
Epoch 8/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3023 - mse:
0.3023 - val_loss: 0.2905 - val_mse: 0.2905
Epoch 9/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2993 - mse:
0.2993 - val_loss: 0.2886 - val_mse: 0.2886
Epoch 10/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3029 - mse:
0.3029 - val_loss: 0.2901 - val_mse: 0.2901
Epoch 11/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3024 - mse:
0.3024 - val_loss: 0.2959 - val_mse: 0.2959
Epoch 12/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3020 - mse:
0.3020 - val_loss: 0.3693 - val_mse: 0.3693
Epoch 13/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3025 - mse:
0.3025 - val_loss: 0.2945 - val_mse: 0.2945
Epoch 14/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3002 - mse:
0.3002 - val_loss: 0.2885 - val_mse: 0.2885
Epoch 15/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2999 - mse:
0.2999 - val_loss: 0.2955 - val_mse: 0.2955
Epoch 16/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2988 - mse:
0.2988 - val_loss: 0.2948 - val_mse: 0.2948
Epoch 17/150
339/339 [==============================] - 2s 7ms/step - loss: 0.3003 - mse:
```

```
0.3003 - val_loss: 0.2916 - val_mse: 0.2916
Epoch 18/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2978 - mse:
0.2978 - val_loss: 0.3066 - val_mse: 0.3066
Epoch 19/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2968 - mse:
0.2968 - val_loss: 0.2870 - val_mse: 0.2870
Epoch 20/150
339/339 [==============================] - 2s 6ms/step - loss: 0.3001 - mse:
0.3001 - val_loss: 0.2903 - val_mse: 0.2903
Epoch 21/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2962 - mse:
0.2962 - val_loss: 0.2901 - val_mse: 0.2901
Epoch 22/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2975 - mse:
0.2975 - val_loss: 0.2951 - val_mse: 0.2951
Epoch 23/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2975 - mse:
0.2975 - val_loss: 0.2924 - val_mse: 0.2924
Epoch 24/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2981 - mse:
0.2981 - val_loss: 0.2882 - val_mse: 0.2882
Epoch 25/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2964 - mse:
0.2964 - val_loss: 0.3064 - val_mse: 0.3064
Epoch 26/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.2948 - val_mse: 0.2948
Epoch 27/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2973 - mse:
0.2973 - val_loss: 0.2893 - val_mse: 0.2893
Epoch 28/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2982 - mse:
0.2982 - val_loss: 0.2879 - val_mse: 0.2879
Epoch 29/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.2870 - val_mse: 0.2870
Epoch 30/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.3361 - val_mse: 0.3361
Epoch 31/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2962 - mse:
0.2962 - val_loss: 0.2860 - val_mse: 0.2860
Epoch 32/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2961 - mse:
0.2961 - val_loss: 0.2978 - val_mse: 0.2978
Epoch 33/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2962 - mse:
0.2962 - val_loss: 0.2973 - val_mse: 0.2973
Epoch 34/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2955 - mse:
0.2955 - val_loss: 0.2957 - val_mse: 0.2957
Epoch 35/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2952 - mse:
0.2952 - val_loss: 0.2862 - val_mse: 0.2862
Epoch 36/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2966 - mse:
0.2966 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 37/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2958 - mse:
0.2958 - val_loss: 0.2900 - val_mse: 0.2900
Epoch 38/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2954 - mse:
0.2954 - val_loss: 0.2852 - val_mse: 0.2852
Epoch 39/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2954 - mse:
0.2954 - val_loss: 0.2858 - val_mse: 0.2858
Epoch 40/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2947 - mse:
```

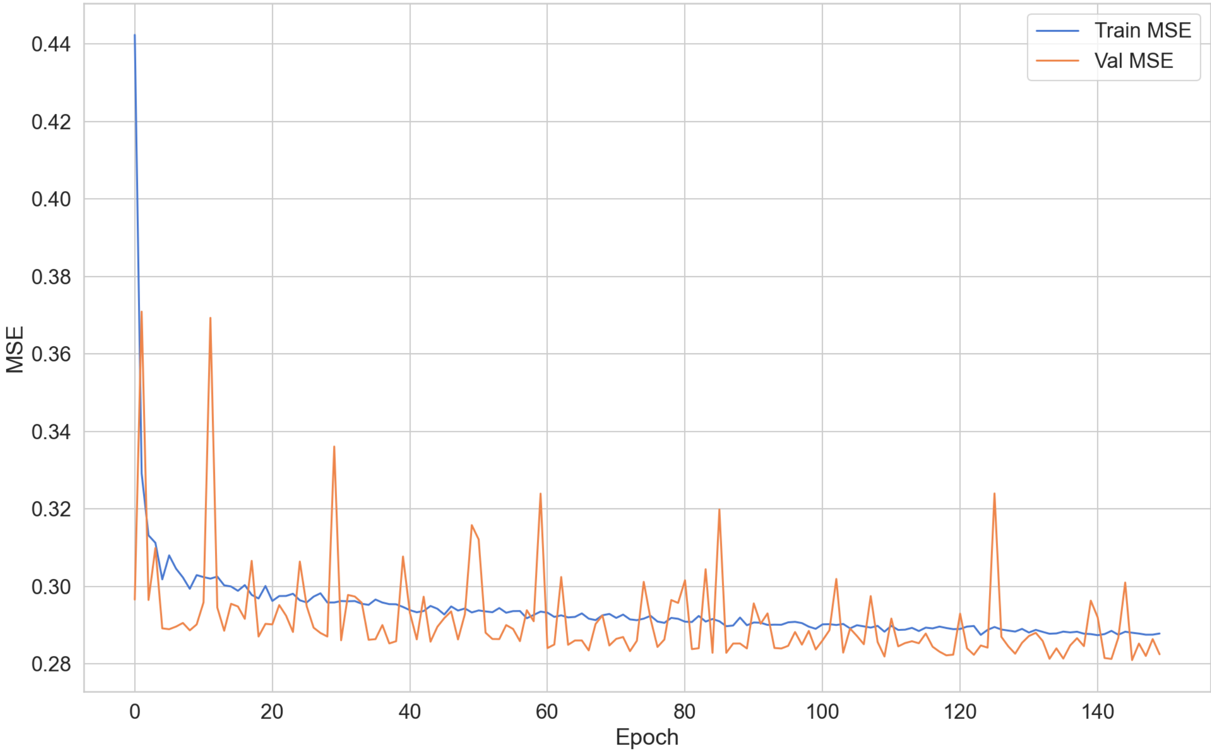
```
0.2947 - val_loss: 0.3077 - val_mse: 0.3077
Epoch 41/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2938 - mse: 
0.2938 - val_loss: 0.2931 - val_mse: 0.2931
Epoch 42/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2933 - mse: 
0.2933 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 43/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2936 - mse: 
0.2936 - val_loss: 0.2973 - val_mse: 0.2973
Epoch 44/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2949 - mse: 
0.2949 - val_loss: 0.2857 - val_mse: 0.2857
Epoch 45/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2942 - mse: 
0.2942 - val_loss: 0.2895 - val_mse: 0.2895
Epoch 46/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2927 - mse: 
0.2927 - val_loss: 0.2918 - val_mse: 0.2918
Epoch 47/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2948 - mse: 
0.2948 - val_loss: 0.2935 - val_mse: 0.2935
Epoch 48/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2937 - mse: 
0.2937 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 49/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2943 - mse: 
0.2943 - val_loss: 0.2928 - val_mse: 0.2928
Epoch 50/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2932 - mse: 
0.2932 - val_loss: 0.3158 - val_mse: 0.3158
Epoch 51/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2938 - mse: 
0.2938 - val_loss: 0.3121 - val_mse: 0.3121
Epoch 52/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2935 - mse: 
0.2935 - val_loss: 0.2880 - val_mse: 0.2880
Epoch 53/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2933 - mse: 
0.2933 - val_loss: 0.2864 - val_mse: 0.2864
Epoch 54/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2944 - mse: 
0.2944 - val_loss: 0.2864 - val_mse: 0.2864
Epoch 55/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2932 - mse: 
0.2932 - val_loss: 0.2900 - val_mse: 0.2900
Epoch 56/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2936 - mse: 
0.2936 - val_loss: 0.2890 - val_mse: 0.2890
Epoch 57/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2936 - mse: 
0.2936 - val_loss: 0.2858 - val_mse: 0.2858
Epoch 58/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2917 - mse: 
0.2917 - val_loss: 0.2938 - val_mse: 0.2938
Epoch 59/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2926 - mse: 
0.2926 - val_loss: 0.2910 - val_mse: 0.2910
Epoch 60/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2935 - mse: 
0.2935 - val_loss: 0.3239 - val_mse: 0.3239
Epoch 61/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2932 - mse: 
0.2932 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 62/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2921 - mse: 
0.2921 - val_loss: 0.2850 - val_mse: 0.2850
Epoch 63/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2925 - mse: 
```

```
0.2925 - val_loss: 0.3024 - val_mse: 0.3024
Epoch 64/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2920 - mse:
0.2920 - val_loss: 0.2849 - val_mse: 0.2849
Epoch 65/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2921 - mse:
0.2921 - val_loss: 0.2860 - val_mse: 0.2860
Epoch 66/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2930 - mse:
0.2930 - val_loss: 0.2860 - val_mse: 0.2860
Epoch 67/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2916 - mse:
0.2916 - val_loss: 0.2834 - val_mse: 0.2834
Epoch 68/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2913 - mse:
0.2913 - val_loss: 0.2903 - val_mse: 0.2903
Epoch 69/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2925 - mse:
0.2925 - val_loss: 0.2925 - val_mse: 0.2925
Epoch 70/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2929 - mse:
0.2929 - val_loss: 0.2847 - val_mse: 0.2847
Epoch 71/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2918 - mse:
0.2918 - val_loss: 0.2864 - val_mse: 0.2864
Epoch 72/150
339/339 [==============================] - 1s 4ms/step - loss: 0.2927 - mse:
0.2927 - val_loss: 0.2869 - val_mse: 0.2869
Epoch 73/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2914 - mse:
0.2914 - val_loss: 0.2832 - val_mse: 0.2832
Epoch 74/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2912 - mse:
0.2912 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 75/150
339/339 [==============================] - 2s 7ms/step - loss: 0.2916 - mse:
0.2916 - val_loss: 0.3011 - val_mse: 0.3011
Epoch 76/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2924 - mse:
0.2924 - val_loss: 0.2915 - val_mse: 0.2915
Epoch 77/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2909 - mse:
0.2909 - val_loss: 0.2843 - val_mse: 0.2843
Epoch 78/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2905 - mse:
0.2905 - val_loss: 0.2863 - val_mse: 0.2863
Epoch 79/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2918 - mse:
0.2918 - val_loss: 0.2964 - val_mse: 0.2964
Epoch 80/150
339/339 [==============================] - 2s 6ms/step - loss: 0.2916 - mse:
0.2916 - val_loss: 0.2957 - val_mse: 0.2957
Epoch 81/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2909 - mse:
0.2909 - val_loss: 0.3015 - val_mse: 0.3015
Epoch 82/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2908 - mse:
0.2908 - val_loss: 0.2838 - val_mse: 0.2838
Epoch 83/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2923 - mse:
0.2923 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 84/150
339/339 [==============================] - 1s 4ms/step - loss: 0.2909 - mse:
0.2909 - val_loss: 0.3044 - val_mse: 0.3044
Epoch 85/150
339/339 [==============================] - 1s 4ms/step - loss: 0.2915 - mse:
0.2915 - val_loss: 0.2828 - val_mse: 0.2828
Epoch 86/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2910 - mse:
```

```
0.2910 - val_loss: 0.3198 - val_mse: 0.3198
Epoch 87/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2897 - mse:
0.2897 - val_loss: 0.2828 - val_mse: 0.2828
Epoch 88/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2899 - mse:
0.2899 - val_loss: 0.2852 - val_mse: 0.2852
Epoch 89/150
339/339 [==============================] - 2s 4ms/step - loss: 0.2919 - mse:
0.2919 - val_loss: 0.2852 - val_mse: 0.2852
Epoch 90/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2899 - mse:
0.2899 - val_loss: 0.2839 - val_mse: 0.2839
Epoch 91/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2906 - mse:
0.2906 - val_loss: 0.2956 - val_mse: 0.2956
Epoch 92/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2906 - mse:
0.2906 - val_loss: 0.2903 - val_mse: 0.2903
Epoch 93/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2900 - mse:
0.2900 - val_loss: 0.2930 - val_mse: 0.2930
Epoch 94/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2901 - mse:
0.2901 - val_loss: 0.2841 - val_mse: 0.2841
Epoch 95/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2901 - mse:
0.2901 - val_loss: 0.2839 - val_mse: 0.2839
Epoch 96/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2907 - mse:
0.2907 - val_loss: 0.2846 - val_mse: 0.2846
Epoch 97/150
339/339 [==============================] - 2s 4ms/step - loss: 0.2908 - mse:
0.2908 - val_loss: 0.2882 - val_mse: 0.2882
Epoch 98/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2905 - mse:
0.2905 - val_loss: 0.2849 - val_mse: 0.2849
Epoch 99/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2896 - mse:
0.2896 - val_loss: 0.2885 - val_mse: 0.2885
Epoch 100/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2837 - val_mse: 0.2837
Epoch 101/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2902 - mse:
0.2902 - val_loss: 0.2860 - val_mse: 0.2860
Epoch 102/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2902 - mse:
0.2902 - val_loss: 0.2886 - val_mse: 0.2886
Epoch 103/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2900 - mse:
0.2900 - val_loss: 0.3019 - val_mse: 0.3019
Epoch 104/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2903 - mse:
0.2903 - val_loss: 0.2829 - val_mse: 0.2829
Epoch 105/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2891 - mse:
0.2891 - val_loss: 0.2891 - val_mse: 0.2891
Epoch 106/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2899 - mse:
0.2899 - val_loss: 0.2872 - val_mse: 0.2872
Epoch 107/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2896 - mse:
0.2896 - val_loss: 0.2850 - val_mse: 0.2850
Epoch 108/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2893 - mse:
0.2893 - val_loss: 0.2975 - val_mse: 0.2975
Epoch 109/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2898 - mse:
```

```
0.2898 - val_loss: 0.2856 - val_mse: 0.2856
Epoch 110/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2819 - val_mse: 0.2819
Epoch 111/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2898 - mse:
0.2898 - val_loss: 0.2917 - val_mse: 0.2917
Epoch 112/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2887 - mse:
0.2887 - val_loss: 0.2845 - val_mse: 0.2845
Epoch 113/150
339/339 [==============================] - 2s 4ms/step - loss: 0.2888 - mse:
0.2888 - val_loss: 0.2853 - val_mse: 0.2853
Epoch 114/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2893 - mse:
0.2893 - val_loss: 0.2858 - val_mse: 0.2858
Epoch 115/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2884 - mse:
0.2884 - val_loss: 0.2853 - val_mse: 0.2853
Epoch 116/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2893 - mse:
0.2893 - val_loss: 0.2878 - val_mse: 0.2878
Epoch 117/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2891 - mse:
0.2891 - val_loss: 0.2844 - val_mse: 0.2844
Epoch 118/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2896 - mse:
0.2896 - val_loss: 0.2831 - val_mse: 0.2831
Epoch 119/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2892 - mse:
0.2892 - val_loss: 0.2822 - val_mse: 0.2822
Epoch 120/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2889 - mse:
0.2889 - val_loss: 0.2823 - val_mse: 0.2823
Epoch 121/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2929 - val_mse: 0.2929
Epoch 122/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2896 - mse:
0.2896 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 123/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2897 - mse:
0.2897 - val_loss: 0.2823 - val_mse: 0.2823
Epoch 124/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2874 - mse:
0.2874 - val_loss: 0.2847 - val_mse: 0.2847
Epoch 125/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2888 - mse:
0.2888 - val_loss: 0.2842 - val_mse: 0.2842
Epoch 126/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2895 - mse:
0.2895 - val_loss: 0.3240 - val_mse: 0.3240
Epoch 127/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2888 - mse:
0.2888 - val_loss: 0.2869 - val_mse: 0.2869
Epoch 128/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2886 - mse:
0.2886 - val_loss: 0.2845 - val_mse: 0.2845
Epoch 129/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2826 - val_mse: 0.2826
Epoch 130/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2890 - mse:
0.2890 - val_loss: 0.2854 - val_mse: 0.2854
Epoch 131/150
339/339 [==============================] - 2s 4ms/step - loss: 0.2881 - mse:
0.2881 - val_loss: 0.2871 - val_mse: 0.2871
Epoch 132/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2887 - mse:
```

```
0.2887 - val_loss: 0.2880 - val_mse: 0.2880
Epoch 133/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2882 - mse:
0.2882 - val_loss: 0.2859 - val_mse: 0.2859
Epoch 134/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2877 - mse:
0.2877 - val_loss: 0.2813 - val_mse: 0.2813
Epoch 135/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2840 - val_mse: 0.2840
Epoch 136/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2813 - val_mse: 0.2813
Epoch 137/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2881 - mse:
0.2881 - val_loss: 0.2847 - val_mse: 0.2847
Epoch 138/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.2866 - val_mse: 0.2866
Epoch 139/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2845 - val_mse: 0.2845
Epoch 140/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2876 - mse:
0.2876 - val_loss: 0.2963 - val_mse: 0.2963
Epoch 141/150
339/339 [==============================] - 2s 4ms/step - loss: 0.2874 - mse:
0.2874 - val_loss: 0.2920 - val_mse: 0.2920
Epoch 142/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2876 - mse:
0.2876 - val_loss: 0.2815 - val_mse: 0.2815
Epoch 143/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2885 - mse:
0.2885 - val_loss: 0.2812 - val_mse: 0.2812
Epoch 144/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2875 - mse:
0.2875 - val_loss: 0.2867 - val_mse: 0.2867
Epoch 145/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2883 - mse:
0.2883 - val_loss: 0.3010 - val_mse: 0.3010
Epoch 146/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2880 - mse:
0.2880 - val_loss: 0.2809 - val_mse: 0.2809
Epoch 147/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2852 - val_mse: 0.2852
Epoch 148/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2875 - mse:
0.2875 - val_loss: 0.2820 - val_mse: 0.2820
Epoch 149/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2875 - mse:
0.2875 - val_loss: 0.2864 - val_mse: 0.2864
Epoch 150/150
339/339 [==============================] - 2s 5ms/step - loss: 0.2878 - mse:
0.2878 - val_loss: 0.2824 - val_mse: 0.2824
```



Neural Network with dropout regularization at 50%

In [31]:

```
model4 = keras.Sequential()
model4.add(keras.layers.Dropout(0.5, input_shape=(X_train.shape[1],)))
model4.add(keras.layers.Dense(units=128, activation="relu"))
model4.add(keras.layers.Dropout(0.5))
model4.add(keras.layers.Dense(units=256, activation="relu"))
model4.add(keras.layers.Dropout(0.5))
model4.add(keras.layers.Dense(units=512, activation="relu"))
model4.add(keras.layers.Dropout(0.5))
model4.add(keras.layers.Dense(1, activation='linear'))

model4.compile(
    optimizer='adam',
    loss = 'mse',
    metrics = ['mse'])

BATCH_SIZE = 64

early_stop = keras.callbacks.EarlyStopping(
  monitor='val_mse',
  mode="min",
  patience=15
)

history = model4.fit(
  x=X_train,
  y=y_train,
  shuffle=True,
  epochs=150,
  validation_split=0.2,
  batch_size=BATCH_SIZE
)

plot_mse(history)
```

```
50
339/339 [==============================] - 2s 5ms/step - loss: 0.6588 - mse:
0.6588 - val_loss: 1.5405 - val_mse: 1.5405
Epoch 3/150
```

```
339/339 [==============================] - 2s 6ms/step - loss: 0.5837 - mse:
0.5837 - val_loss: 0.7010 - val_mse: 0.7010
Epoch 4/150
339/339 [==============================] - 2s 6ms/step - loss: 0.5447 - mse:
0.5447 - val_loss: 0.4953 - val_mse: 0.4953
Epoch 5/150
339/339 [==============================] - 2s 7ms/step - loss: 0.5092 - mse:
0.5092 - val_loss: 0.4250 - val_mse: 0.4250
Epoch 6/150
339/339 [==============================] - 2s 6ms/step - loss: 0.5002 - mse:
0.5002 - val_loss: 0.4216 - val_mse: 0.4216
Epoch 7/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4918 - mse:
0.4918 - val_loss: 0.3627 - val_mse: 0.3627
Epoch 8/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4842 - mse:
0.4842 - val_loss: 0.3674 - val_mse: 0.3674
Epoch 9/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4817 - mse:
0.4817 - val_loss: 0.3785 - val_mse: 0.3785
Epoch 10/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4828 - mse:
0.4828 - val_loss: 0.3759 - val_mse: 0.3759
Epoch 11/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4763 - mse:
0.4763 - val_loss: 0.3830 - val_mse: 0.3830
Epoch 12/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4724 - mse:
0.4724 - val_loss: 0.3468 - val_mse: 0.3468
Epoch 13/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4741 - mse:
0.4741 - val_loss: 0.3618 - val_mse: 0.3618
Epoch 14/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4679 - mse:
0.4679 - val_loss: 0.3486 - val_mse: 0.3486
Epoch 15/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4663 - mse:
0.4663 - val_loss: 0.3529 - val_mse: 0.3529
Epoch 16/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4685 - mse:
0.4685 - val_loss: 0.3367 - val_mse: 0.3367
Epoch 17/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4690 - mse:
0.4690 - val_loss: 0.3568 - val_mse: 0.3568
Epoch 18/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4666 - mse:
0.4666 - val_loss: 0.3368 - val_mse: 0.3368
Epoch 19/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4646 - mse:
0.4646 - val_loss: 0.3456 - val_mse: 0.3456
Epoch 20/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4581 - mse:
0.4581 - val_loss: 0.3372 - val_mse: 0.3372
Epoch 21/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4556 - mse:
0.4556 - val_loss: 0.3530 - val_mse: 0.3530
Epoch 22/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4518 - mse:
0.4518 - val_loss: 0.3370 - val_mse: 0.3370
Epoch 23/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4539 - mse:
0.4539 - val_loss: 0.3287 - val_mse: 0.3287
Epoch 24/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4538 - mse:
0.4538 - val_loss: 0.3525 - val_mse: 0.3525
Epoch 25/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4490 - mse:
0.4490 - val_loss: 0.3362 - val_mse: 0.3362
Epoch 26/150
```

```
339/339 [==============================] - 2s 7ms/step - loss: 0.4486 - mse:
0.4486 - val_loss: 0.3364 - val_mse: 0.3364
Epoch 27/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4513 - mse:
0.4513 - val_loss: 0.3668 - val_mse: 0.3668
Epoch 28/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4446 - mse:
0.4446 - val_loss: 0.3477 - val_mse: 0.3477
Epoch 29/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4501 - mse:
0.4501 - val_loss: 0.3420 - val_mse: 0.3420
Epoch 30/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4473 - mse:
0.4473 - val_loss: 0.3543 - val_mse: 0.3543
Epoch 31/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4454 - mse:
0.4454 - val_loss: 0.3519 - val_mse: 0.3519
Epoch 32/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4418 - mse:
0.4418 - val_loss: 0.3388 - val_mse: 0.3388
Epoch 33/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4399 - mse:
0.4399 - val_loss: 0.3410 - val_mse: 0.3410
Epoch 34/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4444 - mse:
0.4444 - val_loss: 0.3374 - val_mse: 0.3374
Epoch 35/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4378 - mse:
0.4378 - val_loss: 0.3497 - val_mse: 0.3497
Epoch 36/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4381 - mse:
0.4381 - val_loss: 0.3575 - val_mse: 0.3575
Epoch 37/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4383 - mse:
0.4383 - val_loss: 0.3489 - val_mse: 0.3489
Epoch 38/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4384 - mse:
0.4384 - val_loss: 0.3461 - val_mse: 0.3461
Epoch 39/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4322 - mse:
0.4322 - val_loss: 0.3409 - val_mse: 0.3409
Epoch 40/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4381 - mse:
0.4381 - val_loss: 0.3370 - val_mse: 0.3370
Epoch 41/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4324 - mse:
0.4324 - val_loss: 0.3246 - val_mse: 0.3246
Epoch 42/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4316 - mse:
0.4316 - val_loss: 0.3201 - val_mse: 0.3201
Epoch 43/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4382 - mse:
0.4382 - val_loss: 0.3550 - val_mse: 0.3550
Epoch 44/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4327 - mse:
0.4327 - val_loss: 0.3398 - val_mse: 0.3398
Epoch 45/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4319 - mse:
0.4319 - val_loss: 0.3202 - val_mse: 0.3202
Epoch 46/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4291 - mse:
0.4291 - val_loss: 0.3507 - val_mse: 0.3507
Epoch 47/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4265 - mse:
0.4265 - val_loss: 0.3475 - val_mse: 0.3475
Epoch 48/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4291 - mse:
0.4291 - val_loss: 0.3266 - val_mse: 0.3266
Epoch 49/150
```

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339/339 [==============================] - 2s 6ms/step - loss: 0.4299 - mse: 
0.4299 - val_loss: 0.3334 - val_mse: 0.3334
Epoch 50/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4304 - mse: 
0.4304 - val_loss: 0.3333 - val_mse: 0.3333
Epoch 51/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4236 - mse: 
0.4236 - val_loss: 0.3310 - val_mse: 0.3310
Epoch 52/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4271 - mse: 
0.4271 - val_loss: 0.3191 - val_mse: 0.3191
Epoch 53/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4256 - mse: 
0.4256 - val_loss: 0.3541 - val_mse: 0.3541
Epoch 54/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4255 - mse: 
0.4255 - val_loss: 0.3192 - val_mse: 0.3192
Epoch 55/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4250 - mse: 
0.4250 - val_loss: 0.3356 - val_mse: 0.3356
Epoch 56/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4213 - mse: 
0.4213 - val_loss: 0.3345 - val_mse: 0.3345
Epoch 57/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4221 - mse: 
0.4221 - val_loss: 0.3409 - val_mse: 0.3409
Epoch 58/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4243 - mse: 
0.4243 - val_loss: 0.3280 - val_mse: 0.3280
Epoch 59/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4236 - mse: 
0.4236 - val_loss: 0.3243 - val_mse: 0.3243
Epoch 60/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4267 - mse: 
0.4267 - val_loss: 0.3419 - val_mse: 0.3419
Epoch 61/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4232 - mse: 
0.4232 - val_loss: 0.3283 - val_mse: 0.3283
Epoch 62/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4203 - mse: 
0.4203 - val_loss: 0.3287 - val_mse: 0.3287
Epoch 63/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4220 - mse: 
0.4220 - val_loss: 0.3359 - val_mse: 0.3359
Epoch 64/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4226 - mse: 
0.4226 - val_loss: 0.3336 - val_mse: 0.3336
Epoch 65/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4195 - mse: 
0.4195 - val_loss: 0.3279 - val_mse: 0.3279
Epoch 66/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4231 - mse: 
0.4231 - val_loss: 0.3445 - val_mse: 0.3445
Epoch 67/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4170 - mse: 
0.4170 - val_loss: 0.3419 - val_mse: 0.3419
Epoch 68/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4177 - mse: 
0.4177 - val_loss: 0.3253 - val_mse: 0.3253
Epoch 69/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4153 - mse: 
0.4153 - val_loss: 0.3230 - val_mse: 0.3230
Epoch 70/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4144 - mse: 
0.4144 - val_loss: 0.3508 - val_mse: 0.3508
Epoch 71/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4154 - mse: 
0.4154 - val_loss: 0.3284 - val_mse: 0.3284
Epoch 72/150
```

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339/339 [==============================] - 2s 7ms/step - loss: 0.4178 - mse: 0.4178 - val_loss: 0.3356 - val_mse: 0.3356
Epoch 73/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4168 - mse: 0.4168 - val_loss: 0.3351 - val_mse: 0.3351
Epoch 74/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4153 - mse: 0.4153 - val_loss: 0.3411 - val_mse: 0.3411
Epoch 75/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4118 - mse: 0.4118 - val_loss: 0.3292 - val_mse: 0.3292
Epoch 76/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4163 - mse: 0.4163 - val_loss: 0.3280 - val_mse: 0.3280
Epoch 77/150
339/339 [==============================] - 3s 7ms/step - loss: 0.4118 - mse: 0.4118 - val_loss: 0.3237 - val_mse: 0.3237
Epoch 78/150
339/339 [==============================] - 3s 7ms/step - loss: 0.4114 - mse: 0.4114 - val_loss: 0.3220 - val_mse: 0.3220
Epoch 79/150
339/339 [==============================] - 3s 7ms/step - loss: 0.4154 - mse: 0.4154 - val_loss: 0.3369 - val_mse: 0.3369
Epoch 80/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4144 - mse: 0.4144 - val_loss: 0.3300 - val_mse: 0.3300
Epoch 81/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4121 - mse: 0.4121 - val_loss: 0.3107 - val_mse: 0.3107
Epoch 82/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4079 - mse: 0.4079 - val_loss: 0.3376 - val_mse: 0.3376
Epoch 83/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4096 - mse: 0.4096 - val_loss: 0.3372 - val_mse: 0.3372
Epoch 84/150
339/339 [==============================] - 3s 7ms/step - loss: 0.4098 - mse: 0.4098 - val_loss: 0.3169 - val_mse: 0.3169
Epoch 85/150
339/339 [==============================] - 3s 8ms/step - loss: 0.4128 - mse: 0.4128 - val_loss: 0.3386 - val_mse: 0.3386
Epoch 86/150
339/339 [==============================] - 2s 7ms/step - loss: 0.4107 - mse: 0.4107 - val_loss: 0.3634 - val_mse: 0.3634
Epoch 87/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4129 - mse: 0.4129 - val_loss: 0.3195 - val_mse: 0.3195
Epoch 88/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4142 - mse: 0.4142 - val_loss: 0.3286 - val_mse: 0.3286
Epoch 89/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4108 - mse: 0.4108 - val_loss: 0.3345 - val_mse: 0.3345
Epoch 90/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4095 - mse: 0.4095 - val_loss: 0.3277 - val_mse: 0.3277
Epoch 91/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4125 - mse: 0.4125 - val_loss: 0.3234 - val_mse: 0.3234
Epoch 92/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4097 - mse: 0.4097 - val_loss: 0.3243 - val_mse: 0.3243
Epoch 93/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4083 - mse: 0.4083 - val_loss: 0.3231 - val_mse: 0.3231
Epoch 94/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4103 - mse: 0.4103 - val_loss: 0.3221 - val_mse: 0.3221
Epoch 95/150
```
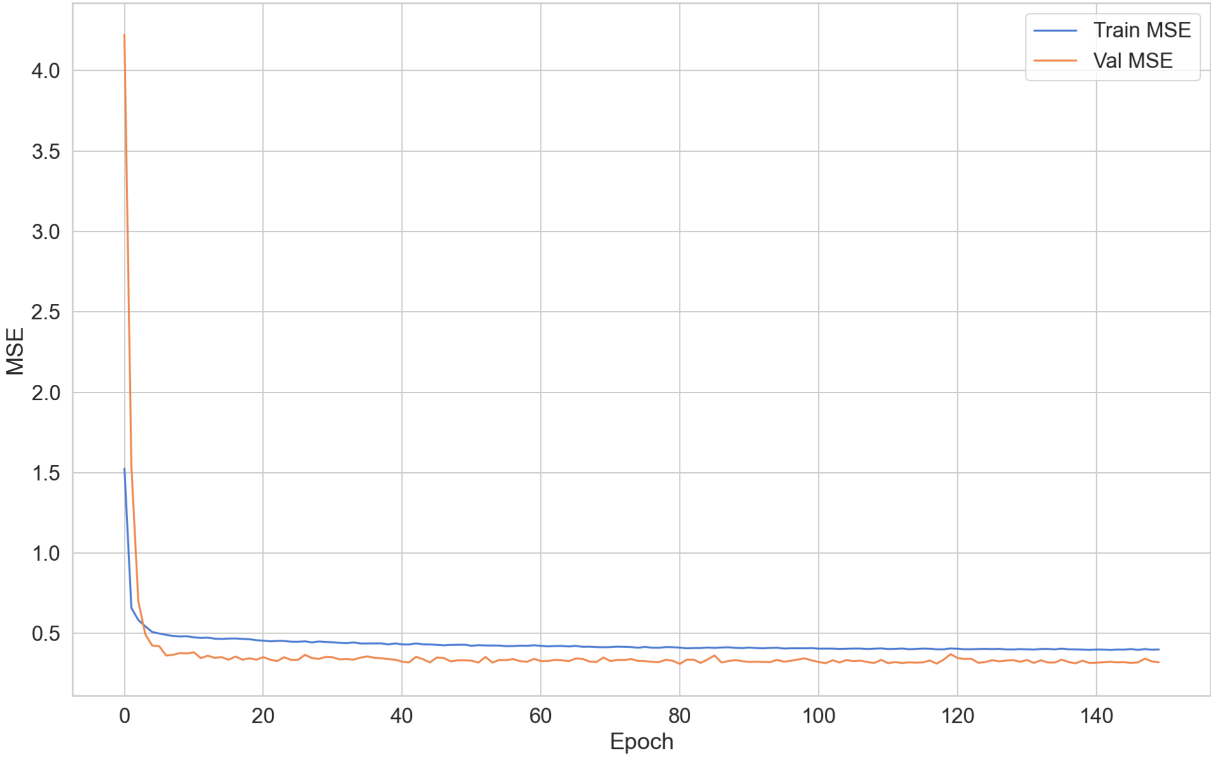

```
339/339 [==============================] - 2s 5ms/step - loss: 0.4115 - mse:
0.4115 - val_loss: 0.3359 - val_mse: 0.3359
Epoch 96/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4065 - mse:
0.4065 - val_loss: 0.3247 - val_mse: 0.3247
Epoch 97/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4082 - mse:
0.4082 - val_loss: 0.3303 - val_mse: 0.3303
Epoch 98/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4082 - mse:
0.4082 - val_loss: 0.3383 - val_mse: 0.3383
Epoch 99/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4080 - mse:
0.4080 - val_loss: 0.3451 - val_mse: 0.3451
Epoch 100/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4093 - mse:
0.4093 - val_loss: 0.3328 - val_mse: 0.3328
Epoch 101/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4057 - mse:
0.4057 - val_loss: 0.3227 - val_mse: 0.3227
Epoch 102/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4060 - mse:
0.4060 - val_loss: 0.3152 - val_mse: 0.3152
Epoch 103/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4060 - mse:
0.4060 - val_loss: 0.3338 - val_mse: 0.3338
Epoch 104/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4037 - mse:
0.4037 - val_loss: 0.3196 - val_mse: 0.3196
Epoch 105/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4049 - mse:
0.4049 - val_loss: 0.3349 - val_mse: 0.3349
Epoch 106/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4063 - mse:
0.4063 - val_loss: 0.3280 - val_mse: 0.3280
Epoch 107/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4062 - mse:
0.4062 - val_loss: 0.3313 - val_mse: 0.3313
Epoch 108/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4034 - mse:
0.4034 - val_loss: 0.3225 - val_mse: 0.3225
Epoch 109/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4055 - mse:
0.4055 - val_loss: 0.3165 - val_mse: 0.3165
Epoch 110/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4075 - mse:
0.4075 - val_loss: 0.3361 - val_mse: 0.3361
Epoch 111/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4031 - mse:
0.4031 - val_loss: 0.3152 - val_mse: 0.3152
Epoch 112/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4042 - mse:
0.4042 - val_loss: 0.3224 - val_mse: 0.3224
Epoch 113/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4066 - mse:
0.4066 - val_loss: 0.3161 - val_mse: 0.3161
Epoch 114/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4022 - mse:
0.4022 - val_loss: 0.3204 - val_mse: 0.3204
Epoch 115/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4037 - mse:
0.4037 - val_loss: 0.3186 - val_mse: 0.3186
Epoch 116/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4063 - mse:
0.4063 - val_loss: 0.3206 - val_mse: 0.3206
Epoch 117/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4050 - mse:
0.4050 - val_loss: 0.3319 - val_mse: 0.3319
Epoch 118/150
```

```
339/339 [==============================] - 2s 5ms/step - loss: 0.4015 - mse:
0.4015 - val_loss: 0.3126 - val_mse: 0.3126
Epoch 119/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4016 - mse:
0.4016 - val_loss: 0.3375 - val_mse: 0.3375
Epoch 120/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4069 - mse:
0.4069 - val_loss: 0.3715 - val_mse: 0.3715
Epoch 121/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4050 - mse:
0.4050 - val_loss: 0.3475 - val_mse: 0.3475
Epoch 122/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4019 - mse:
0.4019 - val_loss: 0.3412 - val_mse: 0.3412
Epoch 123/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4021 - mse:
0.4021 - val_loss: 0.3425 - val_mse: 0.3425
Epoch 124/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4033 - mse:
0.4033 - val_loss: 0.3176 - val_mse: 0.3176
Epoch 125/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4039 - mse:
0.4039 - val_loss: 0.3227 - val_mse: 0.3227
Epoch 126/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4031 - mse:
0.4031 - val_loss: 0.3336 - val_mse: 0.3336
Epoch 127/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4041 - mse:
0.4041 - val_loss: 0.3266 - val_mse: 0.3266
Epoch 128/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4009 - mse:
0.4009 - val_loss: 0.3317 - val_mse: 0.3317
Epoch 129/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4006 - mse:
0.4006 - val_loss: 0.3346 - val_mse: 0.3346
Epoch 130/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4027 - mse:
0.4027 - val_loss: 0.3243 - val_mse: 0.3243
Epoch 131/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4017 - mse:
0.4017 - val_loss: 0.3347 - val_mse: 0.3347
Epoch 132/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4002 - mse:
0.4002 - val_loss: 0.3171 - val_mse: 0.3171
Epoch 133/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4035 - mse:
0.4035 - val_loss: 0.3334 - val_mse: 0.3334
Epoch 134/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4038 - mse:
0.4038 - val_loss: 0.3199 - val_mse: 0.3199
Epoch 135/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4012 - mse:
0.4012 - val_loss: 0.3194 - val_mse: 0.3194
Epoch 136/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4057 - mse:
0.4057 - val_loss: 0.3374 - val_mse: 0.3374
Epoch 137/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4016 - mse:
0.4016 - val_loss: 0.3224 - val_mse: 0.3224
Epoch 138/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4013 - mse:
0.4013 - val_loss: 0.3145 - val_mse: 0.3145
Epoch 139/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4000 - mse:
0.4000 - val_loss: 0.3310 - val_mse: 0.3310
Epoch 140/150
339/339 [==============================] - 2s 5ms/step - loss: 0.3983 - mse:
0.3983 - val_loss: 0.3162 - val_mse: 0.3162
Epoch 141/150
```

```
339/339 [==============================] - 2s 5ms/step - loss: 0.4000 - mse:
0.4000 - val_loss: 0.3184 - val_mse: 0.3184
Epoch 142/150
339/339 [==============================] - 2s 6ms/step - loss: 0.3997 - mse:
0.3997 - val_loss: 0.3210 - val_mse: 0.3210
Epoch 143/150
339/339 [==============================] - 2s 5ms/step - loss: 0.3977 - mse:
0.3977 - val_loss: 0.3242 - val_mse: 0.3242
Epoch 144/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4000 - mse:
0.4000 - val_loss: 0.3205 - val_mse: 0.3205
Epoch 145/150
339/339 [==============================] - 2s 6ms/step - loss: 0.3997 - mse:
0.3997 - val_loss: 0.3218 - val_mse: 0.3218
Epoch 146/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4031 - mse:
0.4031 - val_loss: 0.3168 - val_mse: 0.3168
Epoch 147/150
339/339 [==============================] - 2s 5ms/step - loss: 0.3982 - mse:
0.3982 - val_loss: 0.3207 - val_mse: 0.3207
Epoch 148/150
339/339 [==============================] - 2s 5ms/step - loss: 0.4029 - mse:
0.4029 - val_loss: 0.3439 - val_mse: 0.3439
Epoch 149/150
339/339 [==============================] - 2s 6ms/step - loss: 0.3991 - mse:
0.3991 - val_loss: 0.3264 - val_mse: 0.3264
Epoch 150/150
339/339 [==============================] - 2s 6ms/step - loss: 0.4007 - mse:
0.4007 - val_loss: 0.3213 - val_mse: 0.3213
```



In [32]:

```
import time
import xgboost as xgb
from sklearn.metrics import mean_squared_error, r2_score

xgb_reg_start = time.time()

xgb_reg = xgb.XGBRegressor()
xgb_reg.fit(X_train, y_train)
training_preds_xgb_reg = xgb_reg.predict(X_train)
val_preds_xgb_reg = xgb_reg.predict(X_test)

xgb_reg_end = time.time()
```

```
print(f"Time taken to run: {round((xgb_reg_end - xgb_reg_start)/60,1)} minute
print("\nTraining MSE:", round(mean_squared_error(y_train, training_preds_xgb
print("Validation MSE:", round(mean_squared_error(y_test, val_preds_xgb_reg),
print("\nTraining r2:", round(r2_score(y_train, training_preds_xgb_reg),4))
print("Validation r2:", round(r2_score(y_test, val_preds_xgb_reg),4))
```

```
Time taken to run: 0.0 minutes

Training MSE: 0.1296
Validation MSE: 0.2065

Training r2: 0.7326
Validation r2: 0.5828
```

Model Evaluation

In [33]:
```
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
from math import sqrt
from sklearn.metrics import r2_score
```

In [34]:
```
f = open("Mirko_Lantieri_858278_score1.txt", "a+")
```

In [35]:
```
y_pred = model1.predict(X_test)
```

In [36]:
```
print(f'MSE {mean_squared_error(y_test, y_pred)}')
print(f'MAE {mean_absolute_error(y_test, y_pred)}')
print(f'RMSE {np.sqrt(mean_squared_error(y_test, y_pred))}')
print(f'R2 {r2_score(y_test, y_pred)}')
```

```
MSE 0.2821209050290158
MAE 0.3934433364372566
RMSE 0.5311505483655419
R2 0.4299887470821828
```

In [37]:
```
f.write(f"{np.array2string(np.expm1(y_pred),  separator=',')}\n")
```

Out[37]: 96

In [38]:
```
y_pred = model2.predict(X_test)
```

In [39]:
```
print(f'MSE {mean_squared_error(y_test, y_pred)}')
print(f'MAE {mean_absolute_error(y_test, y_pred)}')
print(f'RMSE {np.sqrt(mean_squared_error(y_test, y_pred))}')
print(f'R2 {r2_score(y_test, y_pred)}')
```

```
MSE 0.2852159162253565
MAE 0.3893421514819327
RMSE 0.534056098387947
R2 0.42373543093873933
```

In [40]:
```
f.write(f"{np.array2string(np.expm1(y_pred),  separator=',')}\n")
```

Out[40]: 96

In [41]:
```
y_pred = model3.predict(X_test)
```

In [42]:
```
print(f'MSE {mean_squared_error(y_test, y_pred)}')
print(f'MAE {mean_absolute_error(y_test, y_pred)}')
print(f'RMSE {np.sqrt(mean_squared_error(y_test, y_pred))}')
print(f'R2 {r2_score(y_test, y_pred)}')
```

```
MSE 0.2863689202705159
MAE 0.3954222547228138
RMSE 0.5351344880219513
R2 0.4214058436281747
```

In [43]:
```
f.write(f"{np.array2string(np.expm1(y_pred),  separator=',')}\n")
```

Out[43]:
```
96
```

In [44]:
```
y_pred = model4.predict(X_test)
```

In [45]:
```
print(f'MSE {mean_squared_error(y_test, y_pred)}')
print(f'MAE {mean_absolute_error(y_test, y_pred)}')
print(f'RMSE {np.sqrt(mean_squared_error(y_test, y_pred))}')
print(f'R2 {r2_score(y_test, y_pred)}')
```

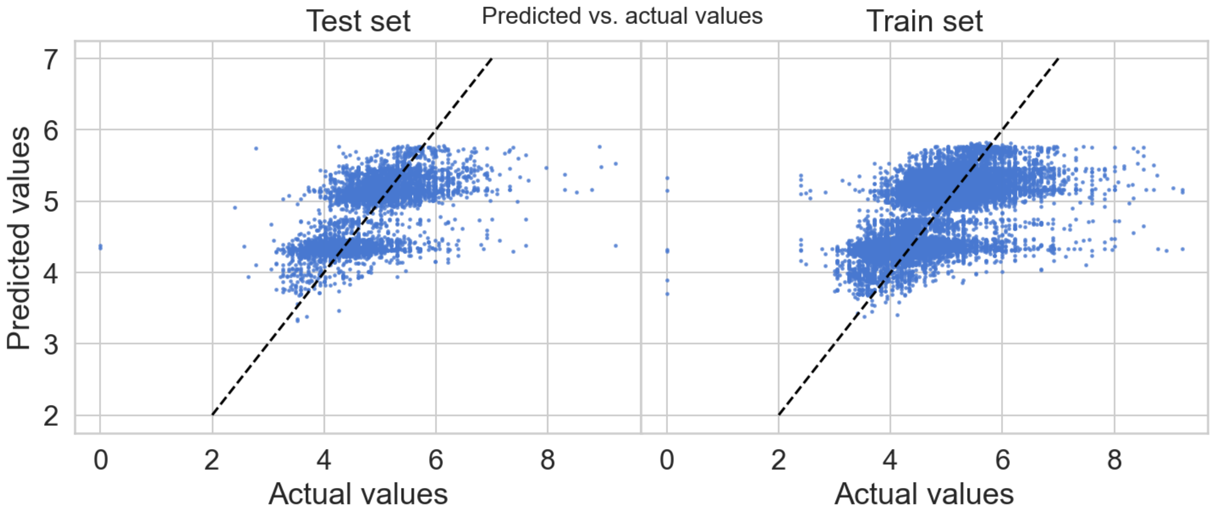
```
MSE 0.323951555103329
MAE 0.424994437956569
RMSE 0.5691674227354628
R2 0.3454719997083088
```

In [46]:
```
f.write(f"{np.array2string(np.expm1(y_pred),  separator=',')}\n")
f.close()
```

In [47]:
```
def nn_model_evaluation(model, skip_epochs=0, X_train=X_train, X_test=X_test,
    """
    For a given neural network model that has already been fit, prints for th
    values, a line graph of the loss in each epoch, and a scatterplot of pred
    representing where predicted = actual values. Optionally, a value for ski
    number of epochs in the line graph of losses (useful in cases where the l
    larger than subsequent epochs). Training and test sets can also optionall
    """

    # MSE and r squared values
    y_test_pred = model.predict(X_test)
    y_train_pred = model.predict(X_train)
    print("Training MSE:", round(mean_squared_error(y_train, y_train_pred),4)
    print("Validation MSE:", round(mean_squared_error(y_test, y_test_pred),4)
    print("\nTraining r2:", round(r2_score(y_train, y_train_pred),4))
    print("Validation r2:", round(r2_score(y_test, y_test_pred),4))


    # Scatterplot of predicted vs. actual values
    fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
    fig.suptitle('Predicted vs. actual values', fontsize=14, y=1)
    plt.subplots_adjust(top=0.93, wspace=0)

    ax1.scatter(y_test, y_test_pred, s=2, alpha=0.7)
    ax1.plot(list(range(2,8)), list(range(2,8)), color='black', linestyle='--
    ax1.set_title('Test set')
    ax1.set_xlabel('Actual values')
    ax1.set_ylabel('Predicted values')

    ax2.scatter(y_train, y_train_pred, s=2, alpha=0.7)
    ax2.plot(list(range(2,8)), list(range(2,8)), color='black', linestyle='--
    ax2.set_title('Train set')
    ax2.set_xlabel('Actual values')
    ax2.set_ylabel('')
    ax2.set_yticklabels(labels='')

    plt.show()
```

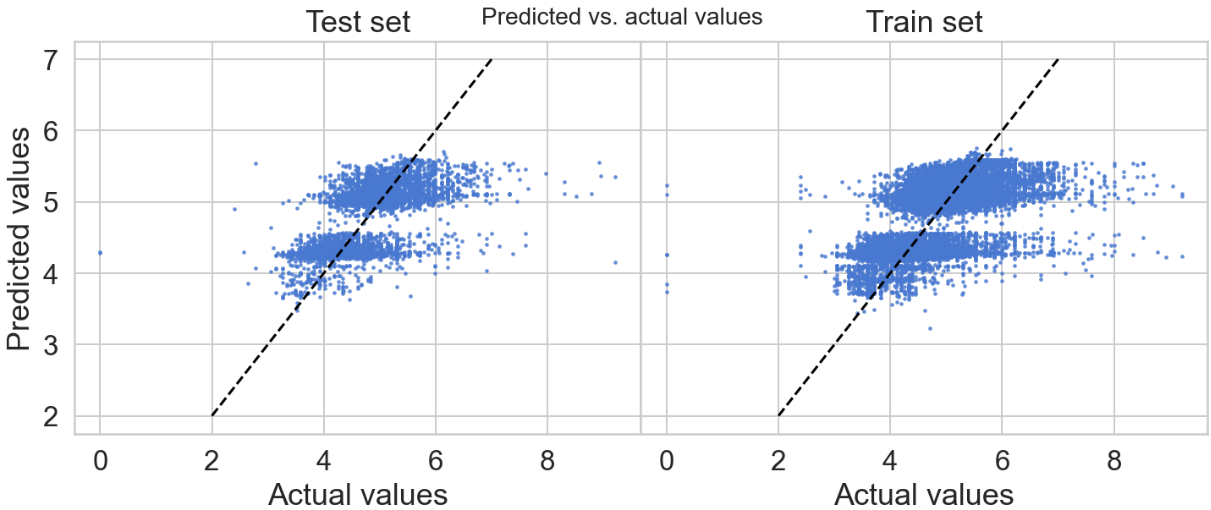
In [48]:
```
nn_model_evaluation(model1)
```

```
Training MSE: 0.281
Validation MSE: 0.2821

Training r2: 0.4203
Validation r2: 0.43
```



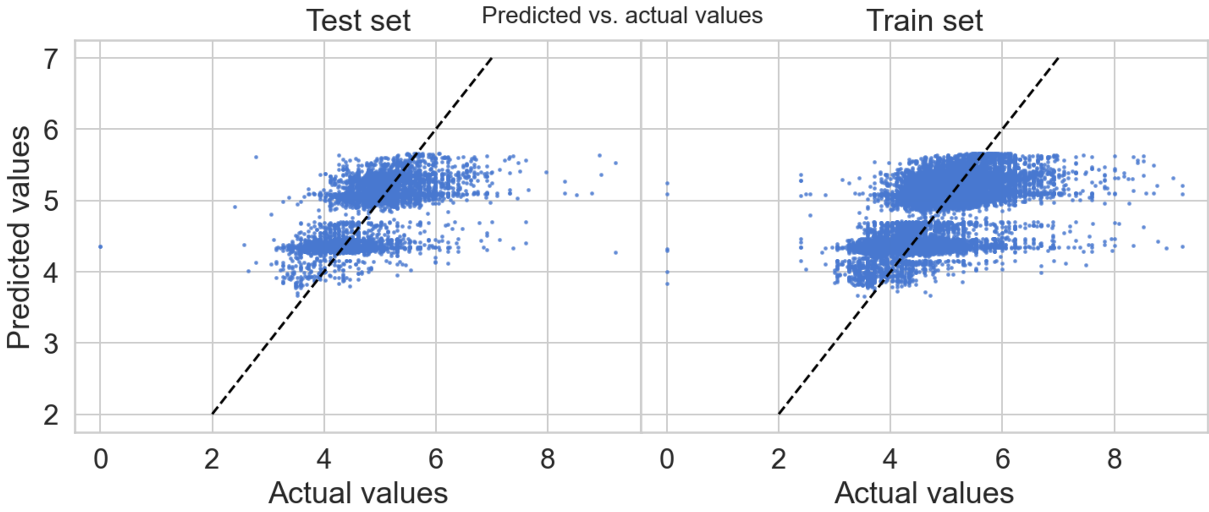
In [49]:
```
nn_model_evaluation(model2)
```

```
Training MSE: 0.2829
Validation MSE: 0.2852

Training r2: 0.4164
Validation r2: 0.4237
```



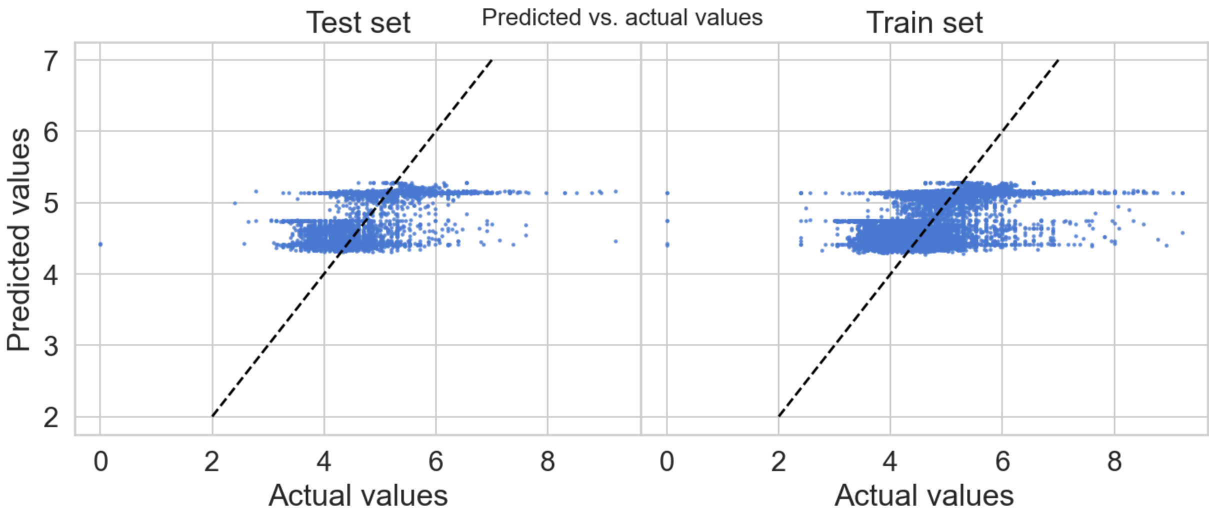
In [50]:
```
nn_model_evaluation(model3)
```

```
Training MSE: 0.2848
Validation MSE: 0.2864

Training r2: 0.4126
Validation r2: 0.4214
```



In [51]:
```
nn_model_evaluation(model4)
```

```
Training MSE: 0.3234
Validation MSE: 0.324

Training r2: 0.3329
Validation r2: 0.3455
```



In [52]:
```
nn_model_evaluation(xgb_reg)
```

```
Training MSE: 0.1296
Validation MSE: 0.2065

Training r2: 0.7326
Validation r2: 0.5828
```