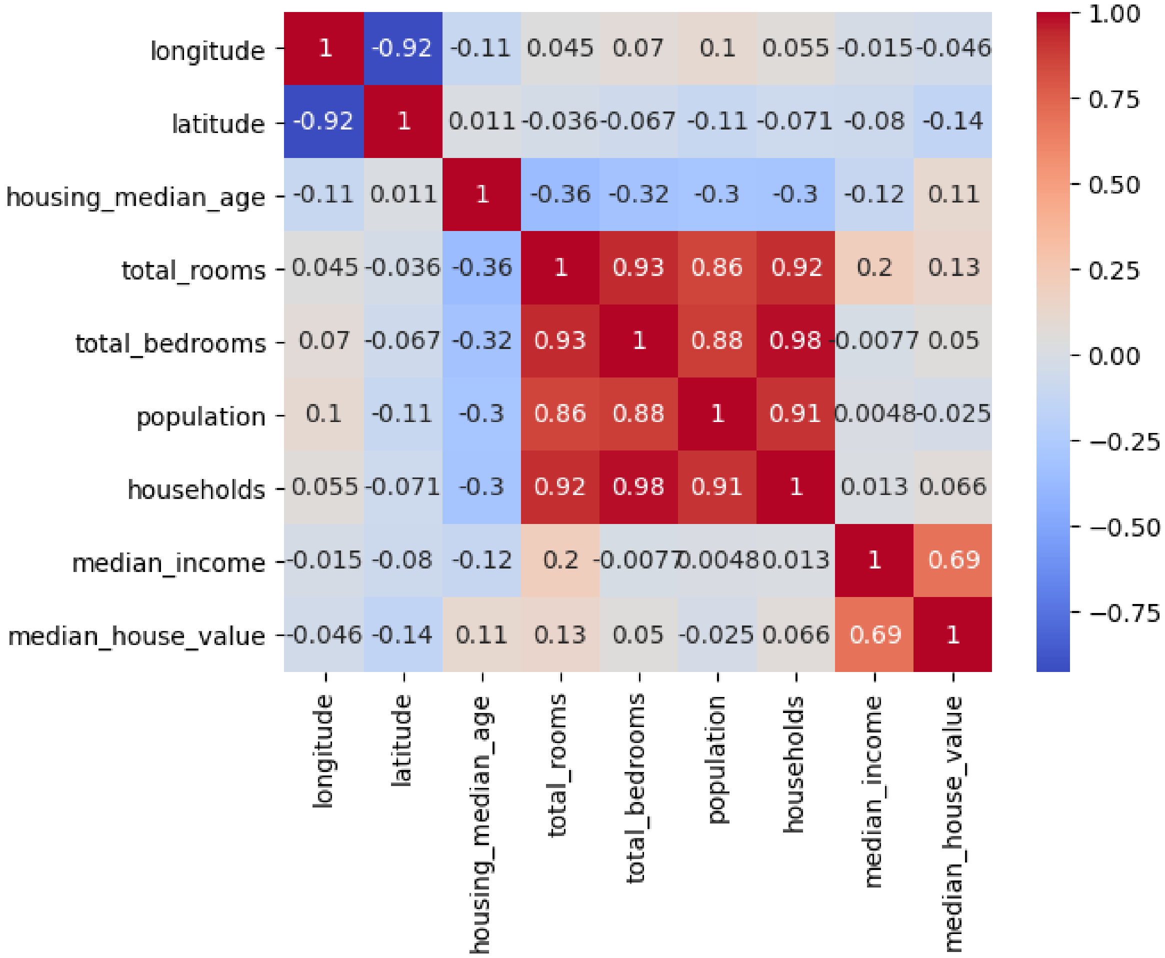
In [ ]:
```
# General data analysis/plotting
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

# Data preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split

# Neural Net modules
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.callbacks import EarlyStopping

# data visualization
import seaborn as sns
import matplotlib.pyplot as plt
```

In [ ]:
```
df = pd.read_csv('boston.csv')
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 20640 entries, 0 to 20639
Data columns (total 10 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   longitude           20640 non-null  float64
 1   latitude            20640 non-null  float64
 2   housing_median_age  20640 non-null  float64
 3   total_rooms         20640 non-null  float64
 4   total_bedrooms      20433 non-null  float64
 5   population          20640 non-null  float64
 6   households          20640 non-null  float64
 7   median_income       20640 non-null  float64
 8   median_house_value  20640 non-null  float64
 9   ocean_proximity     20640 non-null  object 
dtypes: float64(9), object(1)
memory usage: 1.6+ MB
```

In [ ]:
```
sns.heatmap(df.corr(), annot=True, cmap='coolwarm')
```

Out[ ]: <AxesSubplot:>



In [ ]:
```
df.dropna(axis=0, inplace=True)
df = pd.get_dummies(df, columns=['ocean_proximity'])
```

In [ ]:
```
y = df['median_house_value']
X = df.drop(['median_house_value', 'households','total_bedrooms'], axis=1)
print(X.shape, y.shape)

# convert to numpy array
X = np.array(X)
y = np.array(y)

# split into X_train and X_test
# always split into X_train, X_test first THEN apply minmax scaler
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size=0.25,
                                                    random_state=43)

# use minMax scaler
s_scaler = StandardScaler()
X_train = s_scaler.fit_transform(X_train)
X_test = s_scaler.transform(X_test)
```

```
(20433, 10) (20433,)
```

In [ ]:
```
model = Sequential()
model.add(Dense(512, input_shape=(X_train.shape[1],),input_dim = 13 ,activation='re
model.add(Dense(256, activation='relu'))
model.add(Dense(128, activation='relu'))
model.add(Dense(64, activation='relu'))
model.add(Dense(32, activation='relu'))
model.add(Dense(1, activation='linear')) # output node
```

```
model.summary() # see what your model looks like

# compile the model
model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.0015), loss='mean_
# es = EarlyStopping(monitor='val_loss',
#                     mode='min',
#                     patience=50,
#                     restore_best_weights = True)

hist =model.fit(X_train, y_train,
            validation_data=(X_test, y_test),
                    # callbacks=[es],
            epochs=100,
            batch_size=32,
            verbose=1)
```

```
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 dense_36 (Dense)            (None, 512)               5632      
                                                                 
 dense_37 (Dense)            (None, 256)               131328    
                                                                 
 dense_38 (Dense)            (None, 128)               32896     
                                                                 
 dense_39 (Dense)            (None, 64)                8256      
                                                                 
 dense_40 (Dense)            (None, 32)                2080      
                                                                 
 dense_41 (Dense)            (None, 1)                 33        
                                                                 
=================================================================
Total params: 180,225
Trainable params: 180,225
Non-trainable params: 0
_________________________________________________________________
Epoch 1/100
511/511 [==============================] - 5s 6ms/step - loss: 11865627648.0000 - 
mae: 73291.9531 - val_loss: 5420998144.0000 - val_mae: 51421.9609
Epoch 2/100
511/511 [==============================] - 3s 6ms/step - loss: 5185857536.0000 - m
ae: 51195.2812 - val_loss: 5316182016.0000 - val_mae: 50780.7461
Epoch 3/100
511/511 [==============================] - 3s 6ms/step - loss: 5072675328.0000 - m
ae: 50728.6992 - val_loss: 5097619456.0000 - val_mae: 51521.8906
Epoch 4/100
511/511 [==============================] - 3s 6ms/step - loss: 4961001472.0000 - m
ae: 50200.0195 - val_loss: 4982257664.0000 - val_mae: 50927.1406
Epoch 5/100
511/511 [==============================] - 3s 7ms/step - loss: 4923159552.0000 - m
ae: 49842.5820 - val_loss: 5025269760.0000 - val_mae: 50611.7227
Epoch 6/100
511/511 [==============================] - 3s 6ms/step - loss: 4873521664.0000 - m
ae: 49638.3359 - val_loss: 4972419072.0000 - val_mae: 52027.3281
Epoch 7/100
511/511 [==============================] - 3s 6ms/step - loss: 4880892928.0000 - m
ae: 49783.6523 - val_loss: 4993593856.0000 - val_mae: 49566.1914
Epoch 8/100
511/511 [==============================] - 3s 6ms/step - loss: 4854736384.0000 - m
ae: 49422.3945 - val_loss: 4978978816.0000 - val_mae: 50714.8633
Epoch 9/100
511/511 [==============================] - 3s 6ms/step - loss: 4845741056.0000 - m
ae: 49520.9297 - val_loss: 4883512832.0000 - val_mae: 50576.0000
Epoch 10/100
511/511 [==============================] - 3s 6ms/step - loss: 4825505280.0000 - m
ae: 49337.8594 - val_loss: 4989066752.0000 - val_mae: 52870.0078
Epoch 11/100
511/511 [==============================] - 3s 6ms/step - loss: 4799072256.0000 - m
ae: 49083.0898 - val_loss: 4864053248.0000 - val_mae: 49464.5508
Epoch 12/100
511/511 [==============================] - 3s 6ms/step - loss: 4753782272.0000 - m
ae: 48818.9766 - val_loss: 4891373056.0000 - val_mae: 48472.4102
Epoch 13/100
511/511 [==============================] - 3s 6ms/step - loss: 4701876736.0000 - m
ae: 48613.5898 - val_loss: 4825642496.0000 - val_mae: 48346.3477
Epoch 14/100
```

```
511/511 [==============================] - 3s 6ms/step - loss: 4667000320.0000 - m
ae: 48345.5820 - val_loss: 4750699520.0000 - val_mae: 48226.9727
Epoch 15/100
511/511 [==============================] - 3s 6ms/step - loss: 4616715776.0000 - m
ae: 48006.6523 - val_loss: 4710014464.0000 - val_mae: 50171.5625
Epoch 16/100
511/511 [==============================] - 3s 6ms/step - loss: 4525557760.0000 - m
ae: 47422.9336 - val_loss: 4977218560.0000 - val_mae: 47455.8789
Epoch 17/100
511/511 [==============================] - 3s 6ms/step - loss: 4477493760.0000 - m
ae: 47072.3906 - val_loss: 4588754432.0000 - val_mae: 46249.2031
Epoch 18/100
511/511 [==============================] - 3s 6ms/step - loss: 4459772928.0000 - m
ae: 46969.6758 - val_loss: 4547239424.0000 - val_mae: 48025.6914
Epoch 19/100
511/511 [==============================] - 3s 6ms/step - loss: 4373017088.0000 - m
ae: 46493.2422 - val_loss: 4541491712.0000 - val_mae: 46313.8750
Epoch 20/100
511/511 [==============================] - 3s 6ms/step - loss: 4354871296.0000 - m
ae: 46205.2070 - val_loss: 4530420736.0000 - val_mae: 47054.4219
Epoch 21/100
511/511 [==============================] - 3s 6ms/step - loss: 4282085120.0000 - m
ae: 45801.9688 - val_loss: 4562729984.0000 - val_mae: 47065.4453
Epoch 22/100
511/511 [==============================] - 3s 6ms/step - loss: 4241769216.0000 - m
ae: 45550.8203 - val_loss: 4499249152.0000 - val_mae: 47443.1719
Epoch 23/100
511/511 [==============================] - 3s 6ms/step - loss: 4229028864.0000 - m
ae: 45441.7656 - val_loss: 4525226496.0000 - val_mae: 48338.2539
Epoch 24/100
511/511 [==============================] - 3s 7ms/step - loss: 4193313024.0000 - m
ae: 45227.0938 - val_loss: 4789961728.0000 - val_mae: 46385.0625
Epoch 25/100
511/511 [==============================] - 3s 6ms/step - loss: 4197471744.0000 - m
ae: 45278.5625 - val_loss: 4306686464.0000 - val_mae: 46436.9766
Epoch 26/100
511/511 [==============================] - 3s 6ms/step - loss: 4132048384.0000 - m
ae: 44911.1328 - val_loss: 4409722368.0000 - val_mae: 47949.9844
Epoch 27/100
511/511 [==============================] - 3s 6ms/step - loss: 4114443520.0000 - m
ae: 44735.5664 - val_loss: 4216388096.0000 - val_mae: 44228.5234
Epoch 28/100
511/511 [==============================] - 3s 6ms/step - loss: 4075676416.0000 - m
ae: 44479.2070 - val_loss: 4363339776.0000 - val_mae: 46694.1211
Epoch 29/100
511/511 [==============================] - 3s 6ms/step - loss: 4039806208.0000 - m
ae: 44189.6367 - val_loss: 4202859264.0000 - val_mae: 44595.8594
Epoch 30/100
511/511 [==============================] - 3s 6ms/step - loss: 4022004992.0000 - m
ae: 44209.7617 - val_loss: 4156551424.0000 - val_mae: 44343.3281
Epoch 31/100
511/511 [==============================] - 3s 6ms/step - loss: 3965135872.0000 - m
ae: 43821.1172 - val_loss: 4183682304.0000 - val_mae: 45089.0508
Epoch 32/100
511/511 [==============================] - 3s 6ms/step - loss: 3973111552.0000 - m
ae: 43848.7461 - val_loss: 4165714944.0000 - val_mae: 43837.4180
Epoch 33/100
511/511 [==============================] - 3s 6ms/step - loss: 3917075712.0000 - m
ae: 43575.7461 - val_loss: 4141255424.0000 - val_mae: 44519.9062
Epoch 34/100
511/511 [==============================] - 3s 6ms/step - loss: 3901771520.0000 - m
```

```
ae: 43458.9609 - val_loss: 4079457792.0000 - val_mae: 43027.4688
Epoch 35/100
511/511 [==============================] - 3s 6ms/step - loss: 3859162624.0000 - m
ae: 43144.6680 - val_loss: 4039629312.0000 - val_mae: 43248.3828
Epoch 36/100
511/511 [==============================] - 3s 7ms/step - loss: 3824333056.0000 - m
ae: 43012.1367 - val_loss: 4205060608.0000 - val_mae: 43718.5664
Epoch 37/100
511/511 [==============================] - 3s 6ms/step - loss: 3809938688.0000 - m
ae: 42926.8945 - val_loss: 4101959680.0000 - val_mae: 43598.7930
Epoch 38/100
511/511 [==============================] - 3s 6ms/step - loss: 3770759424.0000 - m
ae: 42702.0977 - val_loss: 4037944576.0000 - val_mae: 43178.1719
Epoch 39/100
511/511 [==============================] - 3s 7ms/step - loss: 3780283904.0000 - m
ae: 42548.2031 - val_loss: 4113359104.0000 - val_mae: 42875.7617
Epoch 40/100
511/511 [==============================] - 3s 6ms/step - loss: 3761165824.0000 - m
ae: 42652.7500 - val_loss: 4013829632.0000 - val_mae: 44321.4883
Epoch 41/100
511/511 [==============================] - 3s 6ms/step - loss: 3737419264.0000 - m
ae: 42500.6797 - val_loss: 3892360704.0000 - val_mae: 43342.0508
Epoch 42/100
511/511 [==============================] - 3s 6ms/step - loss: 3741483520.0000 - m
ae: 42457.6406 - val_loss: 3849492736.0000 - val_mae: 42615.4297
Epoch 43/100
511/511 [==============================] - 4s 7ms/step - loss: 3690562816.0000 - m
ae: 42132.7930 - val_loss: 3899945216.0000 - val_mae: 42056.6680
Epoch 44/100
511/511 [==============================] - 3s 6ms/step - loss: 3675741696.0000 - m
ae: 42052.1016 - val_loss: 3940414464.0000 - val_mae: 44003.7578
Epoch 45/100
511/511 [==============================] - 3s 7ms/step - loss: 3663715840.0000 - m
ae: 41988.4375 - val_loss: 3956507648.0000 - val_mae: 41995.5078
Epoch 46/100
511/511 [==============================] - 3s 6ms/step - loss: 3640666624.0000 - m
ae: 41759.9727 - val_loss: 3849888512.0000 - val_mae: 42606.6523
Epoch 47/100
511/511 [==============================] - 3s 6ms/step - loss: 3652971008.0000 - m
ae: 41945.3477 - val_loss: 4039291136.0000 - val_mae: 44923.1680
Epoch 48/100
511/511 [==============================] - 3s 6ms/step - loss: 3605355776.0000 - m
ae: 41599.2734 - val_loss: 3775280128.0000 - val_mae: 42611.3867
Epoch 49/100
511/511 [==============================] - 3s 6ms/step - loss: 3621213952.0000 - m
ae: 41675.8672 - val_loss: 3939573504.0000 - val_mae: 42518.7266
Epoch 50/100
511/511 [==============================] - 3s 6ms/step - loss: 3617739776.0000 - m
ae: 41677.1484 - val_loss: 3938314240.0000 - val_mae: 42117.1211
Epoch 51/100
511/511 [==============================] - 3s 6ms/step - loss: 3576508672.0000 - m
ae: 41465.9141 - val_loss: 3806544640.0000 - val_mae: 41307.5938
Epoch 52/100
511/511 [==============================] - 3s 6ms/step - loss: 3569810176.0000 - m
ae: 41235.1719 - val_loss: 3798776832.0000 - val_mae: 41941.0117
Epoch 53/100
511/511 [==============================] - 3s 6ms/step - loss: 3540645376.0000 - m
ae: 41230.1094 - val_loss: 3868542976.0000 - val_mae: 41889.8828
Epoch 54/100
511/511 [==============================] - 3s 6ms/step - loss: 3594099968.0000 - m
ae: 41558.3945 - val_loss: 3882894592.0000 - val_mae: 43735.3359
```

```
Epoch 55/100
511/511 [==============================] - 3s 6ms/step - loss: 3551541504.0000 - m
ae: 41225.1914 - val_loss: 4061195776.0000 - val_mae: 45541.1328
Epoch 56/100
511/511 [==============================] - 3s 6ms/step - loss: 3524132864.0000 - m
ae: 41067.1172 - val_loss: 3824217856.0000 - val_mae: 43826.7227
Epoch 57/100
511/511 [==============================] - 3s 6ms/step - loss: 3503628800.0000 - m
ae: 40907.7773 - val_loss: 4118211328.0000 - val_mae: 46044.4336
Epoch 58/100
511/511 [==============================] - 3s 6ms/step - loss: 3490440448.0000 - m
ae: 40828.5391 - val_loss: 3908294656.0000 - val_mae: 44974.0898
Epoch 59/100
511/511 [==============================] - 3s 6ms/step - loss: 3493987072.0000 - m
ae: 40981.1484 - val_loss: 3688381696.0000 - val_mae: 41637.9375
Epoch 60/100
511/511 [==============================] - 3s 6ms/step - loss: 3504779520.0000 - m
ae: 40939.0430 - val_loss: 3675129344.0000 - val_mae: 41649.6094
Epoch 61/100
511/511 [==============================] - 2s 5ms/step - loss: 3463587840.0000 - m
ae: 40705.7461 - val_loss: 3712949760.0000 - val_mae: 42430.8477
Epoch 62/100
511/511 [==============================] - 3s 5ms/step - loss: 3458994944.0000 - m
ae: 40601.1484 - val_loss: 3741691648.0000 - val_mae: 41021.4727
Epoch 63/100
511/511 [==============================] - 3s 7ms/step - loss: 3418359296.0000 - m
ae: 40431.1328 - val_loss: 3734126336.0000 - val_mae: 40965.1562
Epoch 64/100
511/511 [==============================] - 2s 5ms/step - loss: 3418958592.0000 - m
ae: 40334.9492 - val_loss: 3659560960.0000 - val_mae: 40682.8984
Epoch 65/100
511/511 [==============================] - 3s 5ms/step - loss: 3429434624.0000 - m
ae: 40576.1094 - val_loss: 3885162496.0000 - val_mae: 43255.5742
Epoch 66/100
511/511 [==============================] - 3s 5ms/step - loss: 3398905344.0000 - m
ae: 40265.6602 - val_loss: 3731041536.0000 - val_mae: 40456.6562
Epoch 67/100
511/511 [==============================] - 2s 5ms/step - loss: 3382921472.0000 - m
ae: 40171.5938 - val_loss: 3790061824.0000 - val_mae: 43463.7266
Epoch 68/100
511/511 [==============================] - 2s 5ms/step - loss: 3382120960.0000 - m
ae: 40183.0586 - val_loss: 3677695744.0000 - val_mae: 41758.4883
Epoch 69/100
511/511 [==============================] - 2s 5ms/step - loss: 3357440512.0000 - m
ae: 40009.0469 - val_loss: 3631145984.0000 - val_mae: 41271.2930
Epoch 70/100
511/511 [==============================] - 2s 5ms/step - loss: 3351677440.0000 - m
ae: 39998.0508 - val_loss: 4058229504.0000 - val_mae: 41996.5391
Epoch 71/100
511/511 [==============================] - 2s 5ms/step - loss: 3369213696.0000 - m
ae: 39984.5820 - val_loss: 3745303040.0000 - val_mae: 41259.2578
Epoch 72/100
511/511 [==============================] - 2s 5ms/step - loss: 3293028352.0000 - m
ae: 39543.5430 - val_loss: 3554318336.0000 - val_mae: 40330.1016
Epoch 73/100
511/511 [==============================] - 2s 4ms/step - loss: 3306288128.0000 - m
ae: 39671.5469 - val_loss: 3925644032.0000 - val_mae: 44143.8672
Epoch 74/100
511/511 [==============================] - 2s 4ms/step - loss: 3320744704.0000 - m
ae: 39698.0078 - val_loss: 3555836672.0000 - val_mae: 41507.2344
Epoch 75/100
```

```
511/511 [==============================] - 2s 4ms/step - loss: 3318072832.0000 - m
ae: 39769.6953 - val_loss: 3728927232.0000 - val_mae: 40604.2109
Epoch 76/100
511/511 [==============================] - 2s 5ms/step - loss: 3305093120.0000 - m
ae: 39572.4414 - val_loss: 3558766336.0000 - val_mae: 40136.8281
Epoch 77/100
511/511 [==============================] - 2s 4ms/step - loss: 3277347840.0000 - m
ae: 39573.6016 - val_loss: 3532697344.0000 - val_mae: 41205.7695
Epoch 78/100
511/511 [==============================] - 2s 4ms/step - loss: 3267146496.0000 - m
ae: 39416.3203 - val_loss: 3623615744.0000 - val_mae: 42514.0938
Epoch 79/100
511/511 [==============================] - 2s 5ms/step - loss: 3237620224.0000 - m
ae: 39202.2852 - val_loss: 3544283136.0000 - val_mae: 40976.4062
Epoch 80/100
511/511 [==============================] - 2s 4ms/step - loss: 3248167936.0000 - m
ae: 39258.2852 - val_loss: 3764462336.0000 - val_mae: 40718.5430
Epoch 81/100
511/511 [==============================] - 2s 4ms/step - loss: 3229481216.0000 - m
ae: 39031.8789 - val_loss: 3524526336.0000 - val_mae: 40265.1172
Epoch 82/100
511/511 [==============================] - 2s 4ms/step - loss: 3214748160.0000 - m
ae: 38995.3320 - val_loss: 3586610432.0000 - val_mae: 40498.1719
Epoch 83/100
511/511 [==============================] - 2s 5ms/step - loss: 3207130624.0000 - m
ae: 38841.1016 - val_loss: 3474672384.0000 - val_mae: 40362.9258
Epoch 84/100
511/511 [==============================] - 2s 4ms/step - loss: 3192024064.0000 - m
ae: 38889.2812 - val_loss: 3477420288.0000 - val_mae: 39867.7578
Epoch 85/100
511/511 [==============================] - 2s 5ms/step - loss: 3156331264.0000 - m
ae: 38669.0234 - val_loss: 3584736256.0000 - val_mae: 41054.6836
Epoch 86/100
511/511 [==============================] - 3s 5ms/step - loss: 3164577792.0000 - m
ae: 38613.8086 - val_loss: 3520935680.0000 - val_mae: 39648.2148
Epoch 87/100
511/511 [==============================] - 3s 6ms/step - loss: 3159503360.0000 - m
ae: 38727.0273 - val_loss: 3858008576.0000 - val_mae: 44319.7266
Epoch 88/100
511/511 [==============================] - 3s 6ms/step - loss: 3147709184.0000 - m
ae: 38628.6094 - val_loss: 3536158976.0000 - val_mae: 39440.3008
Epoch 89/100
511/511 [==============================] - 3s 6ms/step - loss: 3111018752.0000 - m
ae: 38339.0742 - val_loss: 3796092416.0000 - val_mae: 44517.2383
Epoch 90/100
511/511 [==============================] - 3s 5ms/step - loss: 3135062784.0000 - m
ae: 38527.7109 - val_loss: 3500600320.0000 - val_mae: 39898.3633
Epoch 91/100
511/511 [==============================] - 3s 5ms/step - loss: 3097115904.0000 - m
ae: 38288.6289 - val_loss: 3564610304.0000 - val_mae: 40622.7812
Epoch 92/100
511/511 [==============================] - 3s 5ms/step - loss: 3082996992.0000 - m
ae: 38137.7617 - val_loss: 3532196096.0000 - val_mae: 41157.0547
Epoch 93/100
511/511 [==============================] - 3s 5ms/step - loss: 3063203840.0000 - m
ae: 38002.9453 - val_loss: 3378705664.0000 - val_mae: 39313.0312
Epoch 94/100
511/511 [==============================] - 2s 5ms/step - loss: 3062998016.0000 - m
ae: 38033.8438 - val_loss: 3384985600.0000 - val_mae: 40099.3555
Epoch 95/100
511/511 [==============================] - 2s 4ms/step - loss: 3039483136.0000 - m
```

```
ae: 37889.8398 - val_loss: 3356304128.0000 - val_mae: 38251.5352
Epoch 96/100
511/511 [==============================] - 2s 5ms/step - loss: 3028558336.0000 - m
ae: 37857.7852 - val_loss: 3312745984.0000 - val_mae: 39033.9297
Epoch 97/100
511/511 [==============================] - 2s 4ms/step - loss: 3031079168.0000 - m
ae: 37864.8828 - val_loss: 3345870592.0000 - val_mae: 38242.2148
Epoch 98/100
511/511 [==============================] - 2s 5ms/step - loss: 2991137024.0000 - m
ae: 37603.5234 - val_loss: 3405945600.0000 - val_mae: 38791.7812
Epoch 99/100
511/511 [==============================] - 2s 4ms/step - loss: 2987324672.0000 - m
ae: 37586.7500 - val_loss: 3597347584.0000 - val_mae: 39910.2617
Epoch 100/100
511/511 [==============================] - 2s 4ms/step - loss: 2986489344.0000 - m
ae: 37525.2891 - val_loss: 3355273728.0000 - val_mae: 38712.0547
```

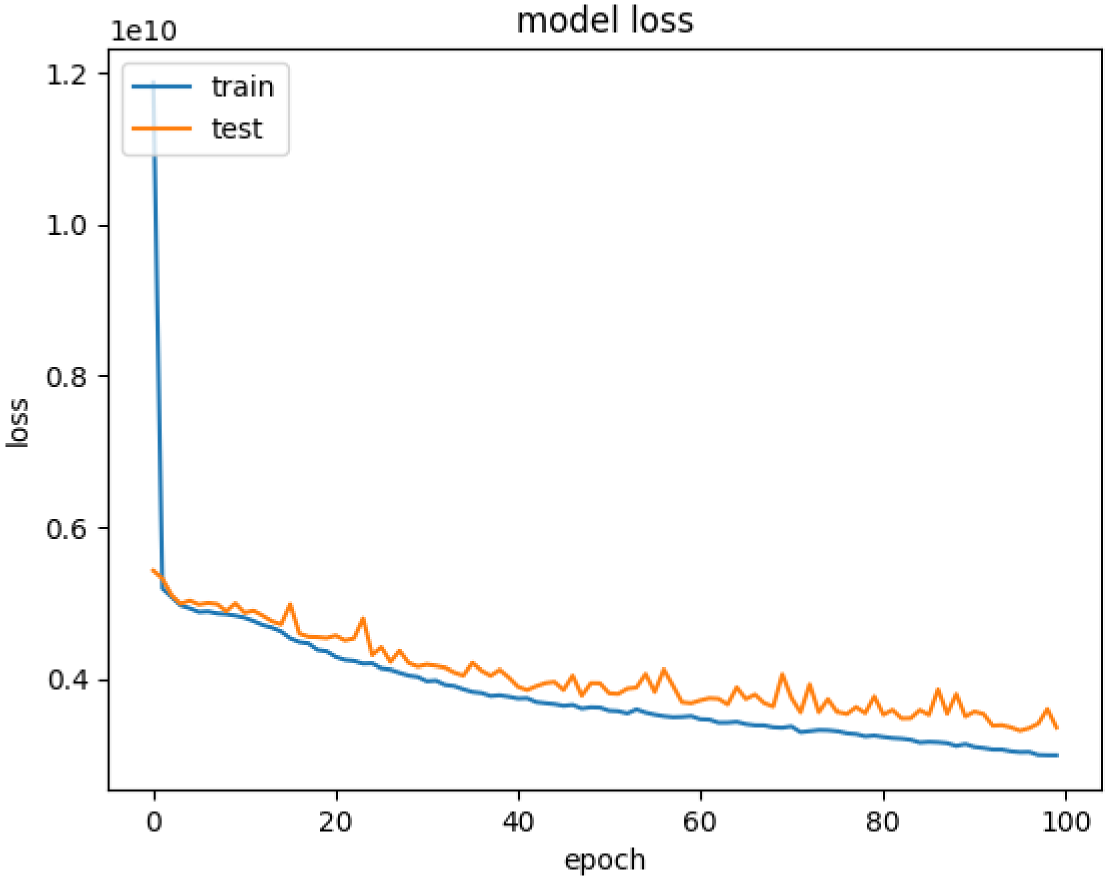
In [ ]:

```
pred = model.predict(X_test)
trainpreds = model.predict(X_train)

from sklearn.metrics import mean_absolute_error
print(mean_absolute_error(y_train, trainpreds)) # train
print(mean_absolute_error(y_test, pred)) # test
```

```
128/128 [==============================] - 1s 3ms/step
511/511 [==============================] - 1s 3ms/step
36437.57292757976
38712.04663701217
```

In [ ]:

```
# plotting validation and training error
import matplotlib.pyplot as plt
import seaborn as sns

plt.plot(hist.history['loss'])
plt.plot(hist.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```


model loss
1e10
1.2
1.0
0.8
0.6
0.4
loss
train
test
0
20
40
60
80
100
epoch