In [67]:

```
from pyspark.sql.types import BooleanType
from pyspark.ml.feature import StringIndexer, VectorAssembler
from pyspark.ml.classification import LinearSVC
from pyspark.sql.session import SparkSession
from pyspark.sql.functions import expr
from pyspark.ml.evaluation import BinaryClassificationEvaluator
from helpers.helper_functions import translate_to_file_string
from pyspark.sql import DataFrameReader
from pyspark.sql import SparkSession
from pyspark.ml.feature import IndexToString, Normalizer, StringInd
from pyspark.ml.evaluation import BinaryClassificationEvaluator
from pyspark.ml.classification import DecisionTreeClassifier
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder
from pyspark.ml import Pipeline
from helpers.helper_functions import translate_to_file_string
from sklearn.metrics import roc_curve, auc
import seaborn as sns
import pandas as pd
import numpy as np
import os
import warnings
import matplotlib.pyplot as plt
warnings.filterwarnings('ignore')
# for pretty printing
def printDf(sprkDF):
    newdf = sprkDF.toPandas()
    from IPython.display import display, HTML
    return HTML(newdf.to_html())
def save_fig(fig_id, tight_layout=True, fig_extension="png", resolu
    path = os.path.join(IMAGES_PATH, fig_id + "." + fig_extension)
    print("Saving figure", fig_id)
    if tight_layout:
        plt.tight_layout()
    plt.savefig(path, format=fig_extension, dpi=resolution)

# Where to save the figures
PROJECT_ROOT_DIR = "."
CHAPTER_ID = "end_to_end_project"
IMAGES_PATH = os.path.join(PROJECT_ROOT_DIR, "images", CHAPTER_ID)
os.makedirs(IMAGES_PATH, exist_ok=True)
```

In [68]:

```
inputFile = translate_to_file_string("../data/heart_val.csv")
```

In [69]:

```
spark = (SparkSession
       .builder
       .appName("HeartDiseaseAnalDT")
       .getOrCreate())
```

In [70]:

```
# load data file.
# create a DataFrame using an ifered Schema
df = spark.read.option("header", "true") \
       .option("inferSchema", "true") \
       .option("delimiter", ";") \
       .csv(inputFile)
print(df.printSchema())

#Pandas df for visualization
dfp = df.toPandas()
```

```
root
 |-- age: integer (nullable = true)
 |-- sex: string (nullable = true)
 |-- cp: integer (nullable = true)
 |-- trestbps: integer (nullable = true)
 |-- chol: integer (nullable = true)
 |-- fbs: integer (nullable = true)
 |-- restecg: integer (nullable = true)
 |-- thalach: integer (nullable = true)
 |-- exang: integer (nullable = true)
 |-- oldpeak: double (nullable = true)
 |-- slope: integer (nullable = true)
 |-- ca: integer (nullable = true)
 |-- thal: integer (nullable = true)
 |-- target: string (nullable = true)

None
```

In [71]:

```
#Show head
dfp.head()
```

Out[71]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	ta
0	63	m	3	145	233	1	0	150	0	2.3	0	0	1	
1	37	m	2	130	250	0	1	187	0	3.5	0	0	2	
2	41	f	1	130	204	0	0	172	0	1.4	2	0	2	
3	56	m	1	120	236	0	1	178	0	0.8	2	0	2	
4	57	f	0	120	354	0	1	163	1	0.6	2	0	2	

In [72]:

```
#Check for empty values
dfp.isnull().sum()
```

Out[72]:

```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

In [73]:

```
# Show summary of data
printDf(df.summary())
```

Out[73]:

	summary	age	sex	cp	trestbps	
0	count	303	303	303	303	
1	mean	54.366336633663366	None	0.966996699669967	131.62376237623764	246.2640
2	stddev	9.08210098983786	None	1.0320524894832983	17.5381428135171	51.8307
3	min	29	f	0	94	
4	25%	47	None	0	120	
5	50%	55	None	1	130	
6	75%	61	None	2	140	
7	max	77	m	3	200	

In [74]:

```
#Show ages in bins
age_groups = pd.cut(dfp['age'], bins=[20, 30,40,50,60,70,80,90])
pd.crosstab(age_groups, dfp['sex'])
```

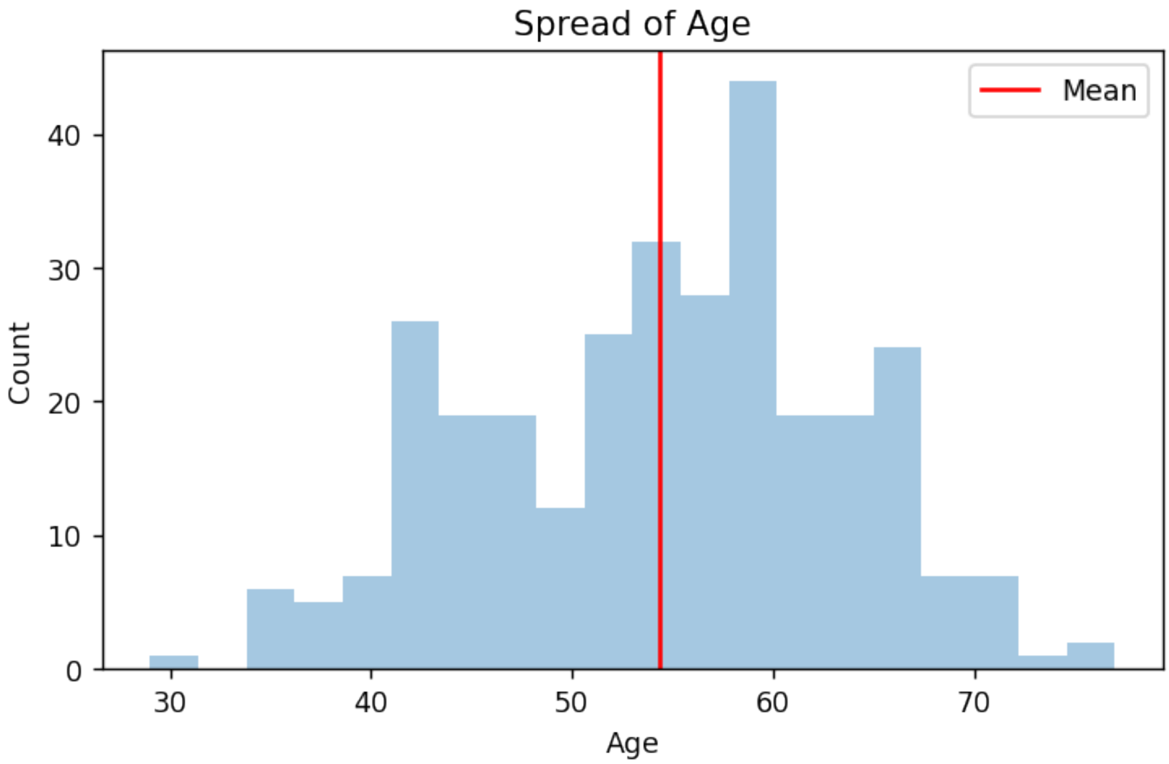
Out[74]:

```
      sex   f   m
      age
(20, 30]    0   1
(30, 40]    5  13
(40, 50]   22  54
(50, 60]   35  94
(60, 70]   29  44
(70, 80]    5   1
```

In [75]:

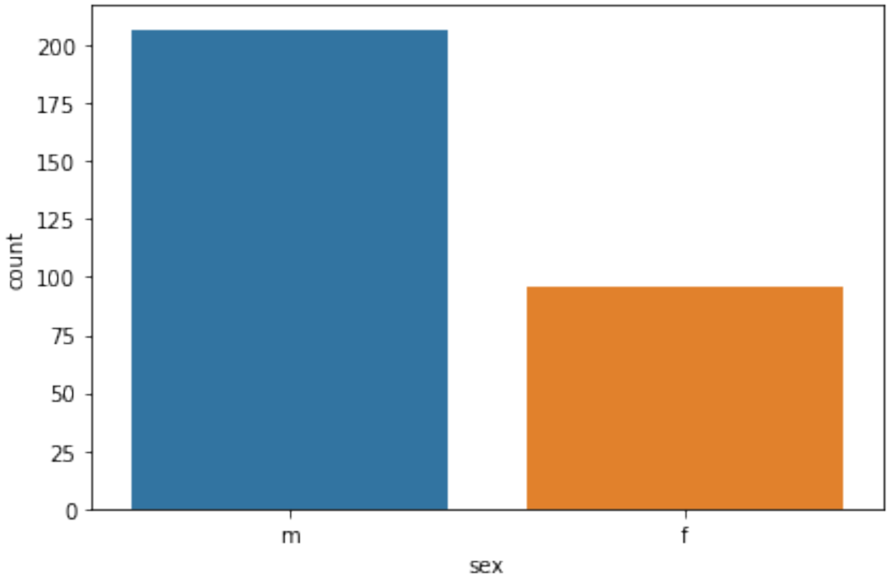
```
#Age visualization
plt.figure(dpi=125)
sns.distplot(a=dfp['age'],kde=False,bins=20)
plt.axvline(x=np.mean(dfp['age']),c='red',label='Mean')
plt.legend()
plt.xlabel('Age')
plt.ylabel('Count')
plt.title('Spread of Age')
save_fig("spread_of_age")
plt.show()
```

```
Saving figure spread_of_age
```



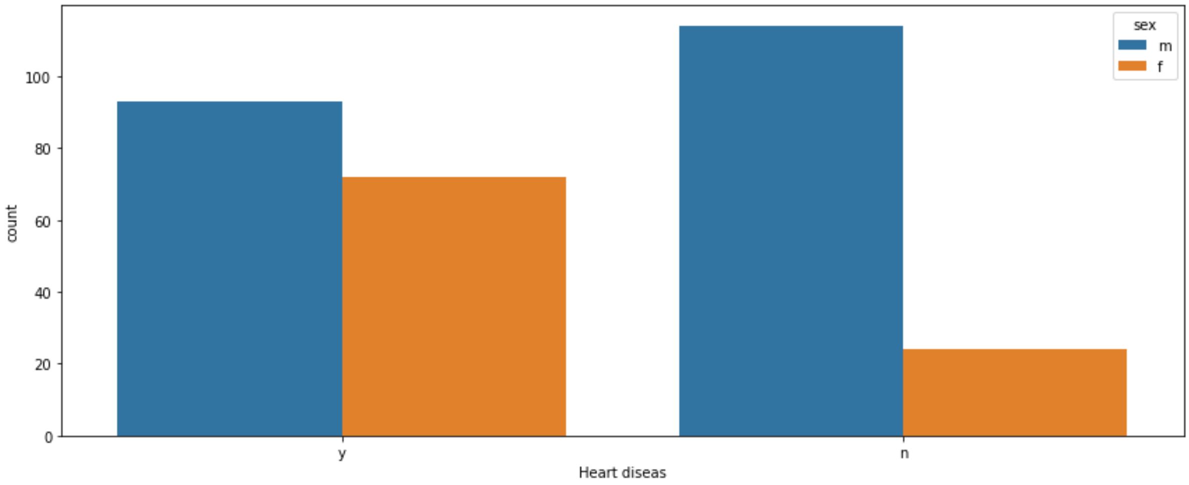
```
In [76]: #Sex comparison m->male; f->female
         dfp.sex.value_counts()
         sns.countplot(dfp.sex)
         save_fig("overview_sex")
         plt.show()
```

```
Saving figure overview_sex
```



```
In [77]: #Comparison  targets over sex
         plt.figure(figsize=(12,5))
         sns.countplot(dfp.target,hue=dfp.sex)
         plt.xlabel('Heart diseas')
         save_fig("heart_diseas_sex")
         plt.show()
```

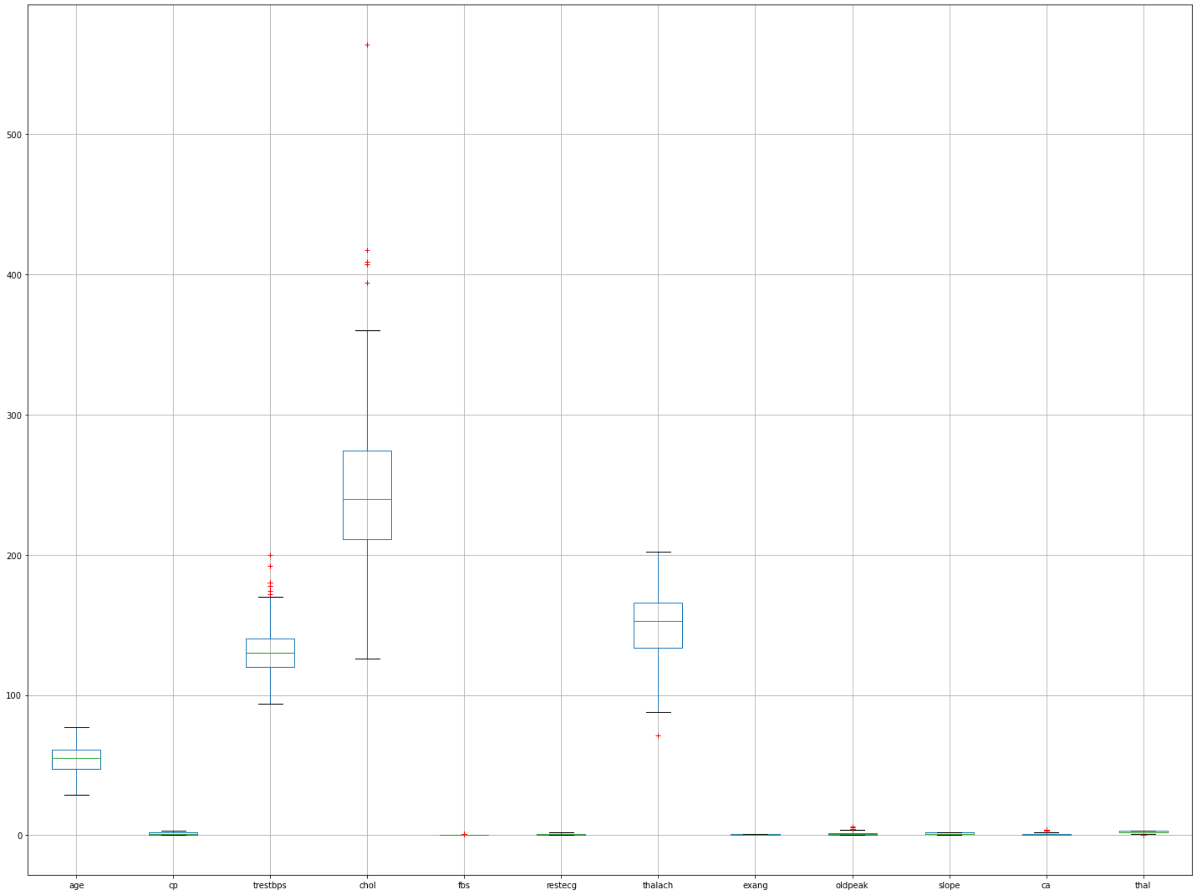
```
Saving figure heart_diseas_sex
```



In [78]:

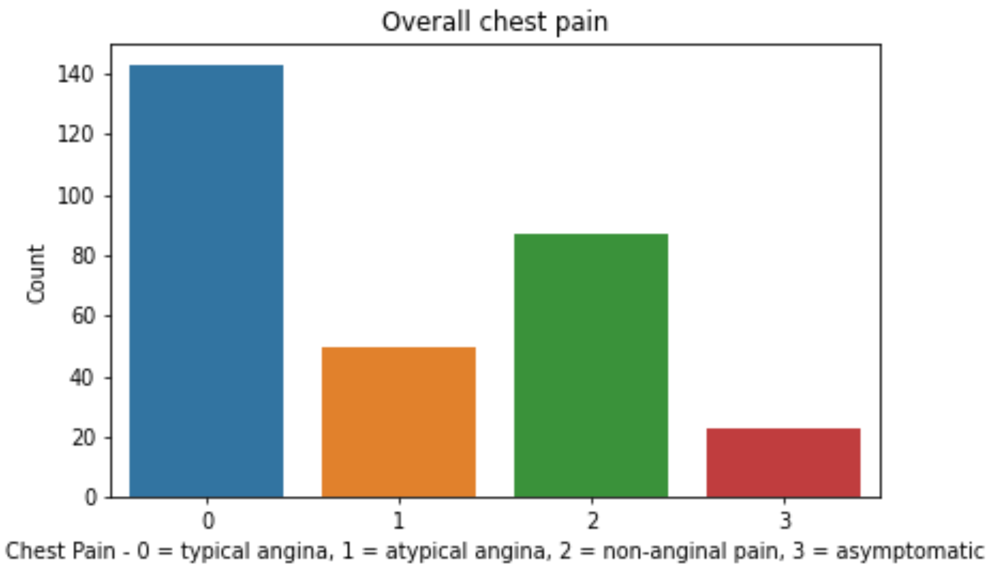
```
#Show all attributes in box plots
%matplotlib inline
df.toPandas().boxplot(sym='r+', figsize=(20,15))
save_fig("attribute_box_plots")
plt.show()
```

```
Saving figure attribute_box_plots
```



In [79]:
```
#Compare chestpain counts
plt.figure(dpi=70)
sns.countplot('cp',data = dfp,)
plt.xlabel('Chest Pain - 0 = typical angina, 1 = atypical angina, 2
plt.ylabel('Count')
plt.title('Overall chest pain')
save_fig("overall_chest_pain")
plt.show()
```

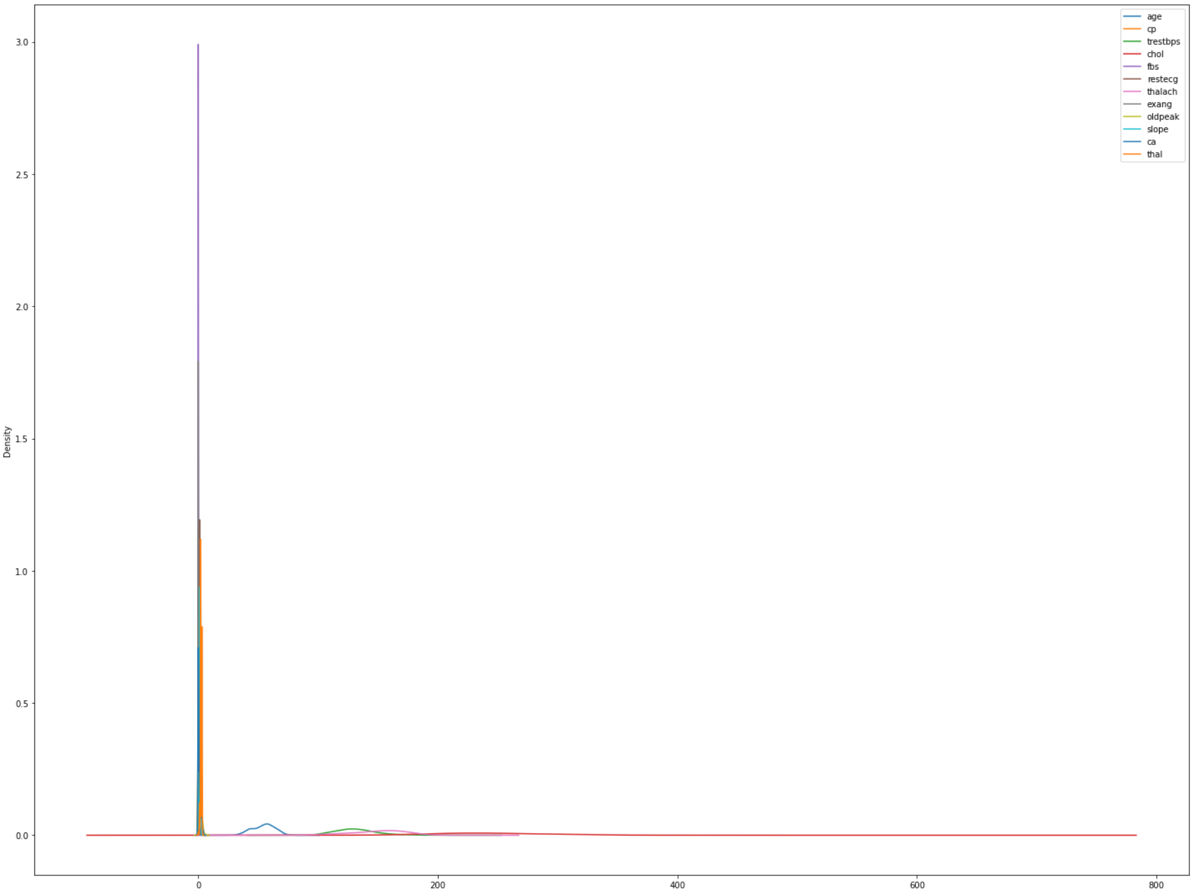
```
Saving figure overall_chest_pain
```



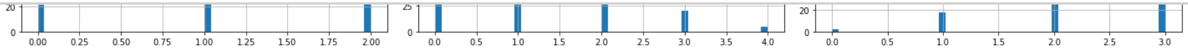
In [80]:

```
#Overall densitiy plot
%matplotlib inline
import matplotlib.pyplot as plt
df.toPandas().plot.kde(figsize=(20,15))
save_fig("attribute_density_plots")
plt.show()
```

```
Saving figure attribute_density_plots
```



In [81]:
```
#Show histograms of each attribute
dfp.hist(bins=50, figsize=(20,15))
save_fig("attribute_histogram_plots")
plt.show()
```

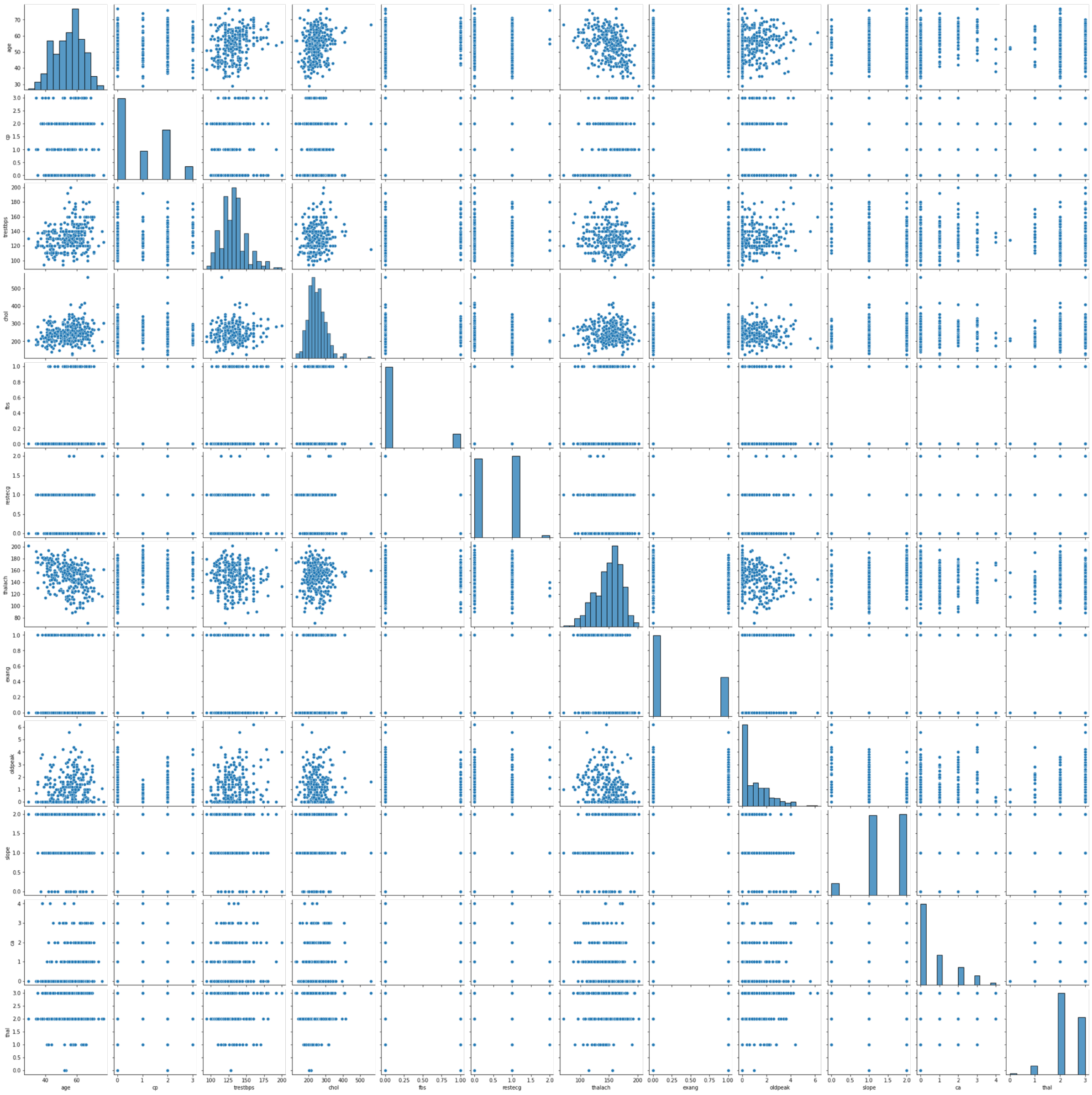


In [82]:

```
#Show all pairplots
sns.pairplot(data=dfp)
```

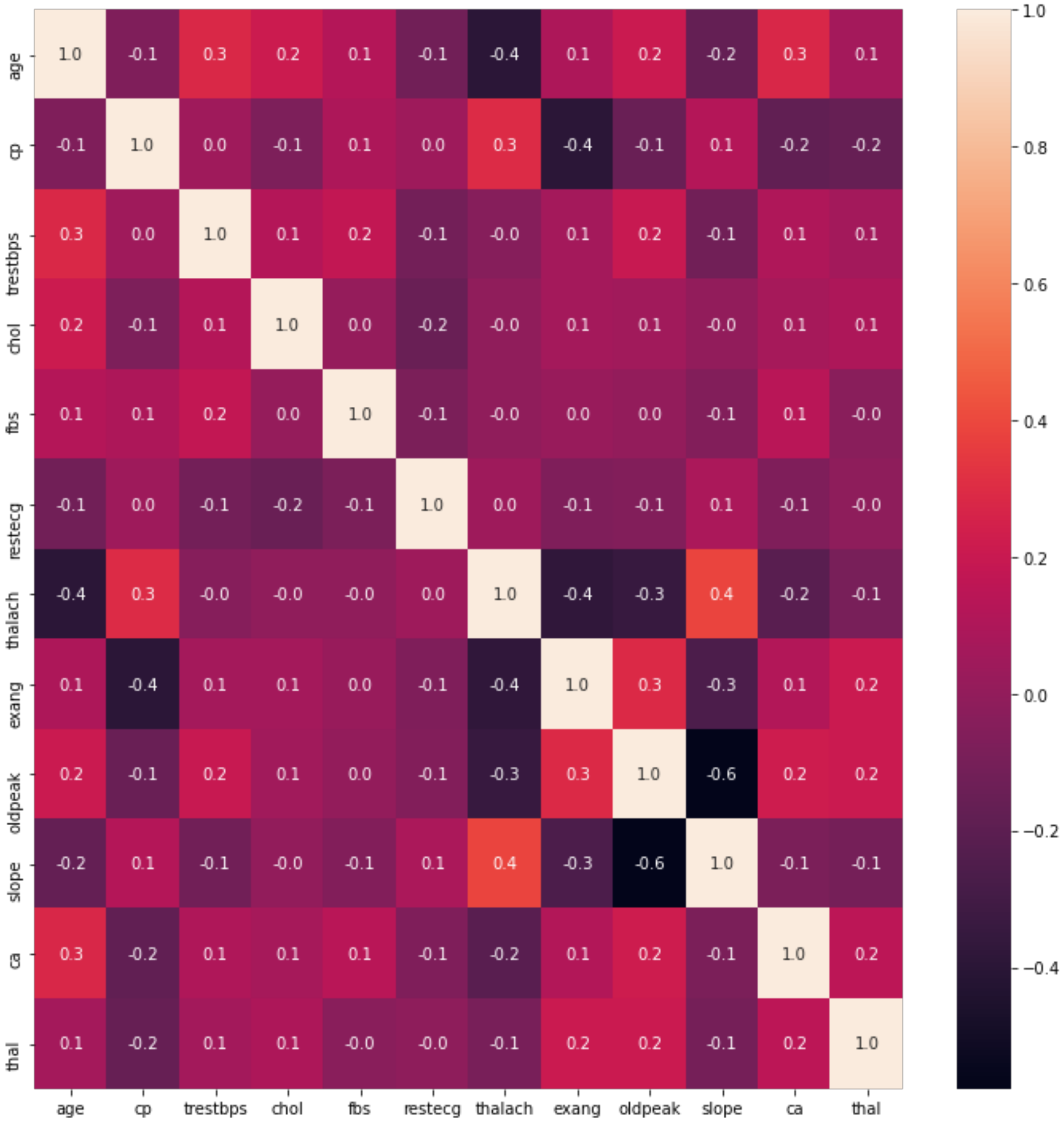
Out[82]:

```
<seaborn.axisgrid.PairGrid at 0x7f90e5460850>
```



```
In [83]: #Show all correlations via heatmap
         plt.figure(figsize=(10,10))
         sns.heatmap(dfp.corr(),annot=True,fmt='.1f')
         save_fig("overall_correlations")
         plt.show()
```

```
Saving figure overall_correlations
```

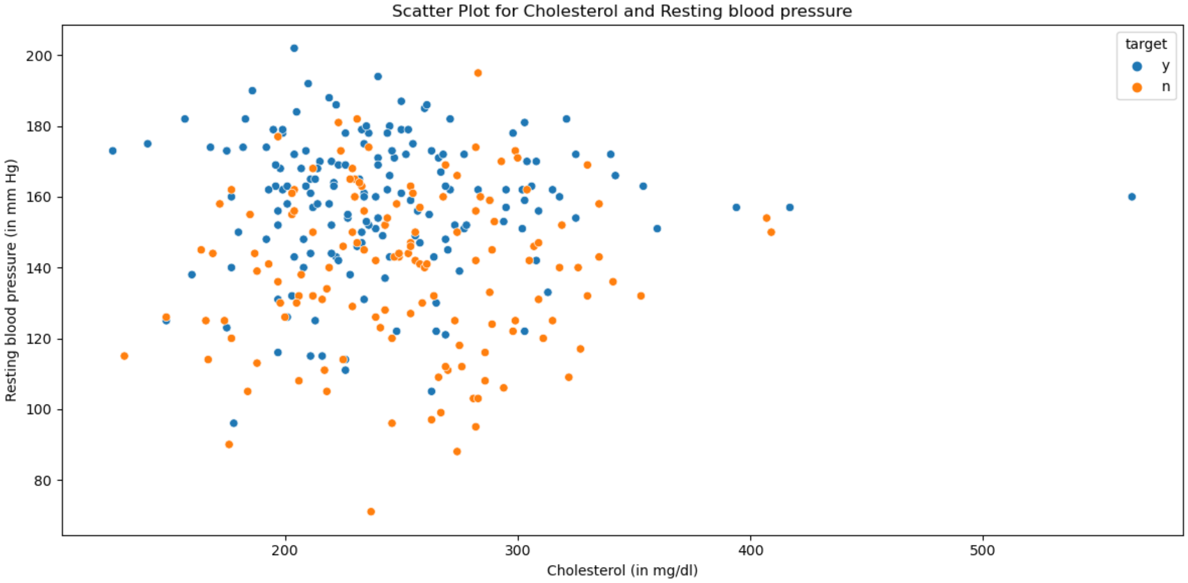


	age	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
age	1.0	-0.1	0.3	0.2	0.1	-0.1	-0.4	0.1	0.2	-0.2	0.3	0.1
cp	-0.1	1.0	0.0	-0.1	0.1	0.0	0.3	-0.4	-0.1	0.1	-0.2	-0.2
trestbps	0.3	0.0	1.0	0.1	0.2	-0.1	-0.0	0.1	0.2	-0.1	0.1	0.1
chol	0.2	-0.1	0.1	1.0	0.0	-0.2	-0.0	0.1	0.1	-0.0	0.1	0.1
fbs	0.1	0.1	0.2	0.0	1.0	-0.1	-0.0	0.0	0.0	-0.1	0.1	-0.0
restecg	-0.1	0.0	-0.1	-0.2	-0.1	1.0	0.0	-0.1	-0.1	0.1	-0.1	-0.0
thalach	-0.4	0.3	-0.0	-0.0	-0.0	0.0	1.0	-0.4	-0.3	0.4	-0.2	-0.1
exang	0.1	-0.4	0.1	0.1	0.0	-0.1	-0.4	1.0	0.3	-0.3	0.1	0.2
oldpeak	0.2	-0.1	0.2	0.1	0.0	-0.1	-0.3	0.3	1.0	-0.6	0.2	0.2
slope	-0.2	0.1	-0.1	-0.0	-0.1	0.1	0.4	-0.3	-0.6	1.0	-0.1	-0.1
ca	0.3	-0.2	0.1	0.1	0.1	-0.1	-0.2	0.1	0.2	-0.1	1.0	0.2
thal	0.1	-0.2	0.1	0.1	-0.0	-0.0	-0.1	0.2	0.2	-0.1	0.2	1.0

In [84]:

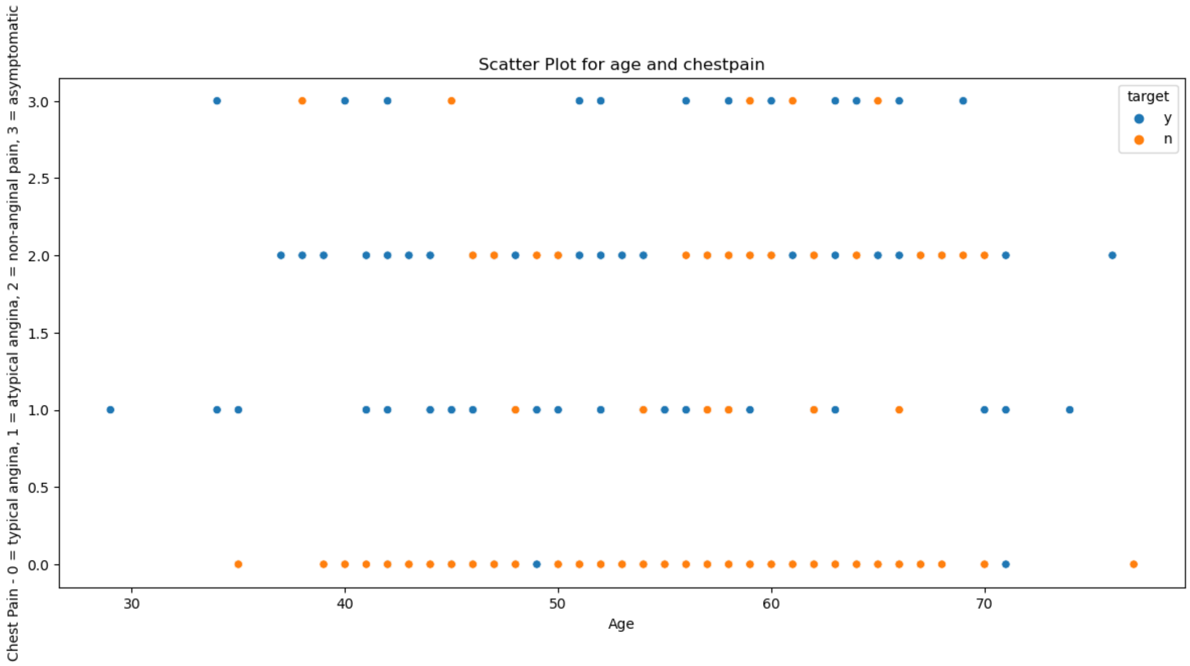
```
#Check for correaltions between cholesterol and blood pressure over
plt.figure(figsize=(12,6),dpi=100)
sns.scatterplot(x='chol',y='thalach',data=dfp,hue='target')
plt.xlabel('Cholesterol (in mg/dl)')
plt.ylabel('Resting blood pressure (in mm Hg)')
plt.title('Scatter Plot for Cholesterol and Resting blood pressure'
save_fig("chol_thalach_target_plot")
plt.show()
```

```
Saving figure chol_thalach_target_plot
```



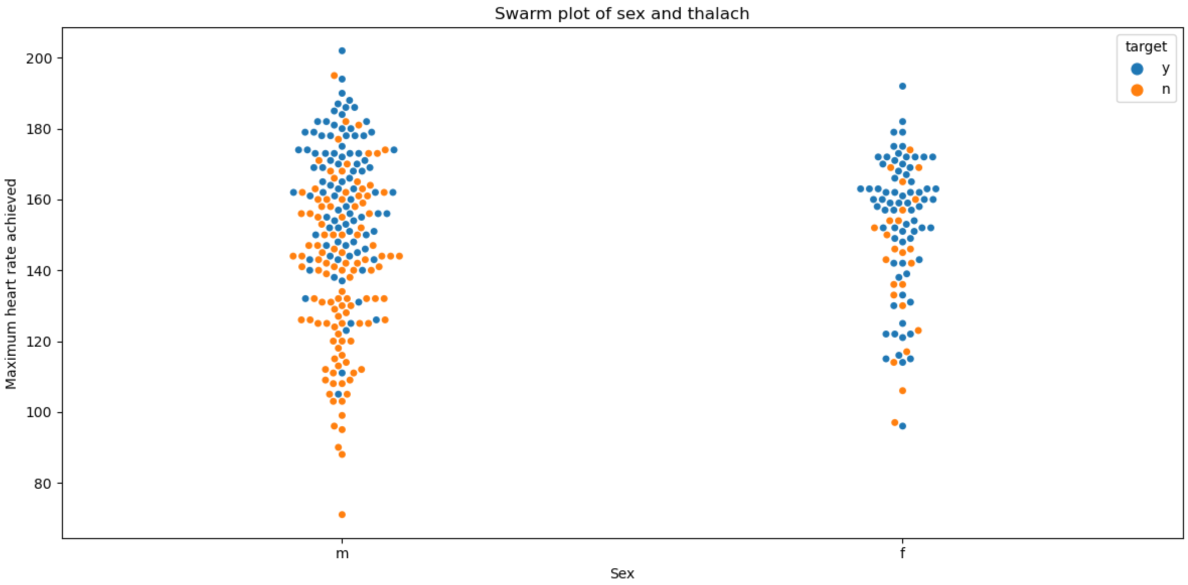
In [85]:
```
#Check correlation of age and chestpain
plt.figure(figsize=(12,6),dpi=100)
sns.scatterplot(x='age',y='cp',data=dfp,hue='target')
plt.xlabel('Age')
plt.ylabel('Chest Pain - 0 = typical angina, 1 = atypical angina, 2
plt.title('Scatter Plot for age and chestpain')
save_fig("age_cp_target_plot")
plt.show()
```

```
Saving figure age_cp_target_plot
```



In [86]:
```
plt.figure(figsize=(12,6),dpi=100)
sns.swarmplot(x='sex',y='thalach',data=dfp,hue='target',dodge=False
plt.xlabel('Sex')
plt.ylabel('Maximum heart rate achieved')
plt.title('Swarm plot of sex and thalach')
save_fig("sex_thalach_target_plot")
plt.show()
```

```
Saving figure sex_thalach_target_plot
```



In [87]:
```
#Show all correlations in exact values
dfp.corr()
```

Out[87]:

	age	cp	trestbps	chol	fbs	restecg	thalach	ex
age	1.000000	-0.068653	0.279351	0.213678	0.121308	-0.116211	-0.398522	0.096
cp	-0.068653	1.000000	0.047608	-0.076904	0.094444	0.044421	0.295762	-0.394
trestbps	0.279351	0.047608	1.000000	0.123174	0.177531	-0.114103	-0.046698	0.067
chol	0.213678	-0.076904	0.123174	1.000000	0.013294	-0.151040	-0.009940	0.067
fbs	0.121308	0.094444	0.177531	0.013294	1.000000	-0.084189	-0.008567	0.025
restecg	-0.116211	0.044421	-0.114103	-0.151040	-0.084189	1.000000	0.044123	-0.070
thalach	-0.398522	0.295762	-0.046698	-0.009940	-0.008567	0.044123	1.000000	-0.378
exang	0.096801	-0.394280	0.067616	0.067023	0.025665	-0.070733	-0.378812	1.000
oldpeak	0.210013	-0.149230	0.193216	0.053952	0.005747	-0.058770	-0.344187	0.288
slope	-0.168814	0.119717	-0.121475	-0.004038	-0.059894	0.093045	0.386784	-0.257
ca	0.276326	-0.181053	0.101389	0.070511	0.137979	-0.072042	-0.213177	0.115
thal	0.068001	-0.161736	0.062210	0.098803	-0.032019	-0.011981	-0.096439	0.206

```
In [88]: spark.stop()
```