In [1]:

```
'''
This Codes From
https://www.kaggle.com/gunesevitan/advanced-feature-engineering-tutorial-with-titanic
Written by Güneş Evitan
'''
```

Out[1]:

```
'₩nThis Codes From₩nhttps://www.kaggle.com/gunesevitan/advanced-feature-engineerin
g-tutorial-with-titanic₩nWritten by Güneş Evitan₩n'
```

In [3]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
sns.set(style="darkgrid")

from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import OneHotEncoder, LabelEncoder, StandardScaler
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import StratifiedKFold

import string
import warnings
warnings.filterwarnings('ignore')

SEED = 42
```

```
C:₩ProgramData₩Anaconda3₩lib₩importlib₩_bootstrap.py:219: RuntimeWarning: numpy.uf
unc size changed, may indicate binary incompatibility. Expected 216, got 192
  return f(*args, **kwds)
C:₩ProgramData₩Anaconda3₩lib₩importlib₩_bootstrap.py:219: RuntimeWarning: numpy.uf
unc size changed, may indicate binary incompatibility. Expected 192 from C header,
got 216 from PyObject
  return f(*args, **kwds)
```

In [5]:

```
def concat_df(train_data, test_data):
    return pd.concat([train_data, test_data], sort=True).reset_index(drop=True)

def divide_df(all_data):
    return all_data.loc[:890], all_data.loc[891:].drop(['Survived'], axis=1)

df_train = pd.read_csv('train.csv')
df_test = pd.read_csv('test.csv')
df_all = concat_df(df_train, df_test)

df_train.name = 'Training Set'
df_test.name = 'Test Set'
df_all.name = 'All Set'

dfs = [df_train, df_test]

print('Number of Training Examples = {}'.format(df_train.shape[0]))
print('Number of Test Examples = {}₩n'.format(df_test.shape[0]))
print('Training X Shape = {}'.format(df_train.shape))
print('Training y Shape  = {}₩n'.format(df_train['Survived'].shape[0]))
print('Test X Shape = {}'.format(df_test.shape))
print('Test y Shape = {}₩n'.format(df_test.shape[0]))
print(df_train.columns)
print(df_test.columns)
```

```
Number of Training Examples = 891
Number of Test Examples = 418

Training X Shape = (891, 12)
Training y Shape  = 891

Test X Shape = (418, 11)
Test y Shape = 418

Index(['PassengerId', 'Survived', 'Pclass', 'Name', 'Sex', 'Age', 'SibSp',
       'Parch', 'Ticket', 'Fare', 'Cabin', 'Embarked'],
      dtype='object')
Index(['PassengerId', 'Pclass', 'Name', 'Sex', 'Age', 'SibSp', 'Parch',
       'Ticket', 'Fare', 'Cabin', 'Embarked'],
      dtype='object')
```

In [6]:

```
print(df_train.info())
df_train.sample(3)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
PassengerId    891 non-null int64
Survived       891 non-null int64
Pclass         891 non-null int64
Name           891 non-null object
Sex            891 non-null object
Age            714 non-null float64
SibSp          891 non-null int64
Parch          891 non-null int64
Ticket         891 non-null object
Fare           891 non-null float64
Cabin          204 non-null object
Embarked       889 non-null object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.6+ KB
None
```

Out[6]:

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare
550	551	1	1	Thayer, Mr. John Borland Jr	male	17.0	0	2	17421	110.8833
524	525	0	3	Kassem, Mr. Fared	male	NaN	0	0	2700	7.2292
779	780	1	1	Robert, Mrs. Edward Scott (Elisabeth Walton Mc...	female	43.0	0	1	24160	211.3375

In [7]:

```
print(df_test.info())
df_test.sample(3)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 418 entries, 0 to 417
Data columns (total 11 columns):
PassengerId    418 non-null int64
Pclass         418 non-null int64
Name           418 non-null object
Sex            418 non-null object
Age            332 non-null float64
SibSp          418 non-null int64
Parch          418 non-null int64
Ticket         418 non-null object
Fare           417 non-null float64
Cabin          91 non-null object
Embarked       418 non-null object
dtypes: float64(2), int64(4), object(5)
memory usage: 36.0+ KB
None
```

Out[7]:

	PassengerId	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Emb
238	1130	2	Hiltunen, Miss. Marta	female	18.0	1	1	250650	13.0	NaN	
30	922	2	Louch, Mr. Charles Alexander	male	50.0	1	0	SC/AH 3085	26.0	NaN	
175	1067	2	Brown, Miss. Edith Eileen	female	15.0	0	2	29750	39.0	NaN	

In [9]:

```
def display_missing(df):
    for col in df.columns.tolist():
        print('{} column missing values: {}'.format(col, df[col].isnull().sum()))
    print('₩n')

for df in dfs:
    print('{}',format(df.name))
    display_missing(df)
```

```
{} Training Set
PassengerId column missing values: 0
Survived column missing values: 0
Pclass column missing values: 0
Name column missing values: 0
Sex column missing values: 0
Age column missing values: 177
SibSp column missing values: 0
Parch column missing values: 0
Ticket column missing values: 0
Fare column missing values: 0
Cabin column missing values: 687
Embarked column missing values: 2


{} Test Set
PassengerId column missing values: 0
Pclass column missing values: 0
Name column missing values: 0
Sex column missing values: 0
Age column missing values: 86
SibSp column missing values: 0
Parch column missing values: 0
Ticket column missing values: 0
Fare column missing values: 1
Cabin column missing values: 327
Embarked column missing values: 0
```

In [12]:

```
df_all_corr = df_all.corr().abs().unstack().sort_values(kind="quicksort",
                                                          ascending=False).reset_index()
df_all_corr.rename(columns={"level_0": "Feature 1", "level_1": "Feature 2", 0: 'Correlation Coef
ficient'},
                  inplace=True)
df_all_corr[df_all_corr['Feature 1'] == 'Age']
```

Out[12]:

	Feature 1	Feature 2	Correlation Coefficient
6	Age	Age	1.000000
9	Age	Pclass	0.408106
17	Age	SibSp	0.243699
22	Age	Fare	0.178740
25	Age	Parch	0.150917
29	Age	Survived	0.077221
41	Age	PassengerId	0.028814

In [13]:

```
age_by_pclass_sex = df_all.groupby(['Sex', 'Pclass']).median()['Age']

for pclass in range(1, 4):
    for sex in ['female', 'male']:
        print('Median age of Pclass {} {}s: {}'.format(pclass, sex,
                                                         age_by_pclass_sex[sex][pclass]))
print('Median age of all passengers: {}'.format(df_all['Age'].median()))

df_all['Age'] = df_all.groupby(['Sex', 'Pclass'])['Age'].apply(lambda x: x.fillna(x.median()))
```

```
Median age of Pclass 1 females: 36.0
Median age of Pclass 1 males: 42.0
Median age of Pclass 2 females: 28.0
Median age of Pclass 2 males: 29.5
Median age of Pclass 3 females: 22.0
Median age of Pclass 3 males: 25.0
Median age of all passengers: 28.0
```

In [14]:

```
df_all[df_all['Embarked'].isnull()]
```

Out[14]:

	Age	Cabin	Embarked	Fare	Name	Parch	PassengerId	Pclass	Sex	SibSp	Sur
61	38.0	B28	NaN	80.0	Icard, Miss. Amelie	0	62	1	female	0	
829	62.0	B28	NaN	80.0	Stone, Mrs. George Nelson (Martha Evelyn)	0	830	1	female	0	

In [15]:

```
df_all['Embarked'] = df_all['Embarked'].fillna('S')
```

In [16]:

```
df_all[df_all['Fare'].isnull()]
```

Out[16]:

	Age	Cabin	Embarked	Fare	Name	Parch	PassengerId	Pclass	Sex	SibSp	Surv
1043	60.5	NaN	S	NaN	Storey, Mr. Thomas	0	1044	3	male	0	

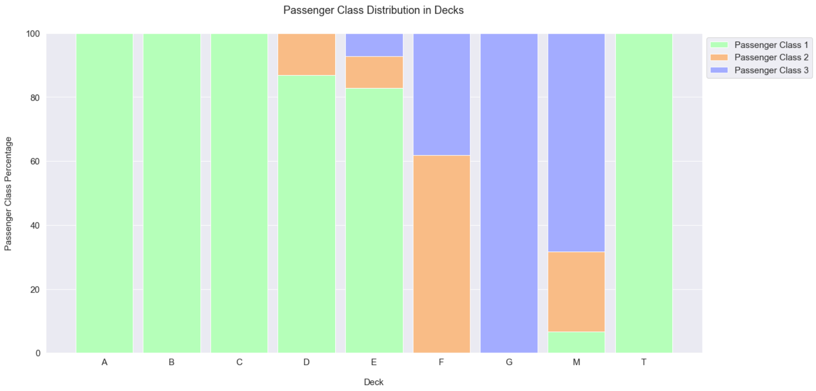
In [17]:

```
med_fare = df_all.groupby(['Pclass', 'Parch', 'SibSp']).Fare.median()[3][0][0]
df_all['Fare'] = df_all['Fare'].fillna(med_fare)
```

In [34]:

```
df_all['Deck'] = df_all['Cabin'].apply(lambda s: s[0] if pd.notnull(s) else 'M')

df_all_decks = df_all.groupby(₩
    ['Deck', 'Pclass']).count().drop(₩
    columns=['Survived', 'Sex', 'Age', 'SibSp', 'Parch', 'Fare', ₩
             'Embarked', 'Cabin', 'PassengerId', 'Ticket']).rename(
    columns={'Name': 'Count'}).transpose()

def get_pclass_dist(df):
    deck_counts = ₩
    {'A': {}, 'B': {}, 'C': {}, 'D': {}, 'E': {}, 'F': {}, 'G': {}, 'M': {}, 'T': {}}
    decks = df.columns.levels[0]

    for deck in decks:
        for pclass in range(1, 4):
            try:
                count = df[deck][pclass][0]
                deck_counts[deck][pclass] = count
            except KeyError:
                deck_counts[deck][pclass] = 0

    df_decks = pd.DataFrame(deck_counts)
    deck_percentages = {}

    for col in df_decks.columns:
        deck_percentages[col] = ₩
        [(count / df_decks[col].sum()) * 100 for count in df_decks[col]]

    return deck_counts, deck_percentages

def display_pclass_dist(percentages):

    df_percentages = pd.DataFrame(percentages).transpose()
    deck_names = ('A', 'B', 'C', 'D', 'E', 'F', 'G', 'M', 'T')
    bar_count = np.arange(len(deck_names))
    bar_width = 0.85

    pclass1 = df_percentages[0]
    pclass2 = df_percentages[1]
    pclass3 = df_percentages[2]

    plt.figure(figsize=(20, 10))
    plt.bar(bar_count, pclass1, color='#b5ffb9', edgecolor='white', width=bar_width, label='Pass
enger Class 1')
    plt.bar(bar_count, pclass2, bottom=pclass1, color='#f9bc86', edgecolor='white', width=bar_wi
dth, label='Passenger Class 2')
    plt.bar(bar_count, pclass3, bottom=pclass1 + pclass2, color='#a3acff', edgecolor='white', wi
dth=bar_width, label='Passenger Class 3')

    plt.xlabel('Deck', size=15, labelpad=20)
    plt.ylabel('Passenger Class Percentage', size=15, labelpad=20)
    plt.xticks(bar_count, deck_names)
    plt.tick_params(axis='x', labelsize=15)
    plt.tick_params(axis='y', labelsize=15)

    plt.legend(loc='upper left', bbox_to_anchor=(1, 1), prop={'size': 15})
    plt.title('Passenger Class Distribution in Decks', size=18, y=1.05)

    plt.show()
```

```
all_deck_count, all_deck_per = get_pclass_dist(df_all_decks)
display_pclass_dist(all_deck_per)
```

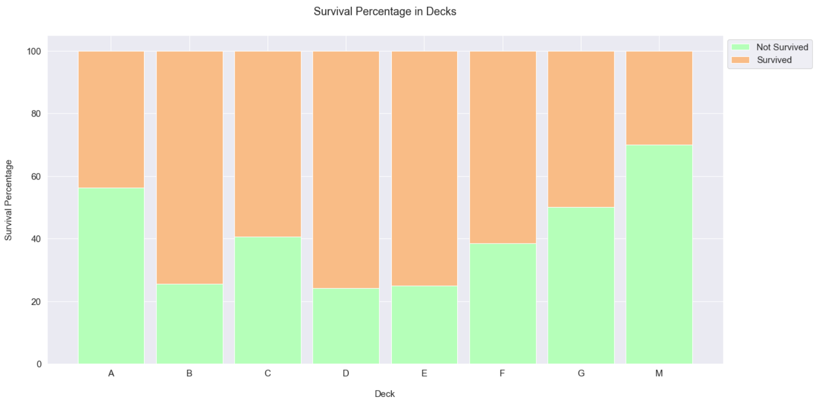


In [35]:

```
idx = df_all[df_all['Deck'] == 'T'].index
df_all.loc[idx, 'Deck'] = 'A'
```

In [46]:

```
df_all_decks_survived = df_all.groupby(['Deck', 'Survived']).count().drop(
    columns=['Sex', 'Age', 'SibSp', 'Parch', 'Fare',
             'Embarked', 'Pclass', 'Cabin', 'PassengerId', 'Ticket']).rename(
columns = {'Name':'Count'}).transpose()

def get_survived_dist(df):
    surv_counts = {'A':{},
                   'B':{}, 'C':{}, 'D':{}, 'E':{}, 'F':{}, 'G':{}, 'M':{}}
    decks = df.columns.levels[0]

    for deck in decks:
        for survive in range(0, 2):
            surv_counts[deck][survive] = df[deck][survive][0]

    df_surv = pd.DataFrame(surv_counts)
    surv_percentages = {}

    for col in df_surv.columns:
        surv_percentages[col] = ₩
        [(count / df_surv[col].sum()) * 100 for count in df_surv[col]]

    return surv_counts, surv_percentages

def display_surv_dist(percentages):

    df_survived_percentages = pd.DataFrame(percentages).transpose()
    deck_names = ('A', 'B', 'C', 'D', 'E', 'F', 'G', 'M')
    bar_count = np.arange(len(deck_names))
    bar_width = 0.85

    not_survived = df_survived_percentages[0]
    survived = df_survived_percentages[1]

    plt.figure(figsize=(20, 10))
    plt.bar(bar_count, not_survived, color='#b5ffb9', edgecolor='white',
            width=bar_width, label='Not Survived')
    plt.bar(bar_count, survived, bottom=not_survived, color='#f9bc86',
            edgecolor='white', width=bar_width, label='Survived')

    plt.xlabel('Deck', size=15, labelpad=20)
    plt.ylabel('Survival Percentage', size=15, labelpad=20)
    plt.xticks(bar_count, deck_names)
    plt.tick_params(axis='x', labelsize=15)
    plt.tick_params(axis='y', labelsize=15)

    plt.legend(loc='upper left', bbox_to_anchor=(1, 1), prop={'size': 15})
    plt.title('Survival Percentage in Decks', size=18, y=1.05)

    plt.show()

all_surv_count, all_surv_per = get_survived_dist(df_all_decks_survived)
display_surv_dist(all_surv_per)
```



In [47]:

```
df_all['Deck'] = df_all['Deck'].replace(['A', 'B', 'C'], 'ABC')
df_all['Deck'] = df_all['Deck'].replace(['D', 'E'], 'DE')
df_all['Deck'] = df_all['Deck'].replace(['F', 'G'], 'FG')

df_all['Deck'].value_counts()
```

Out[47]:

```
M      1014
ABC     182
DE       87
FG       26
Name: Deck, dtype: int64
```

In [48]:

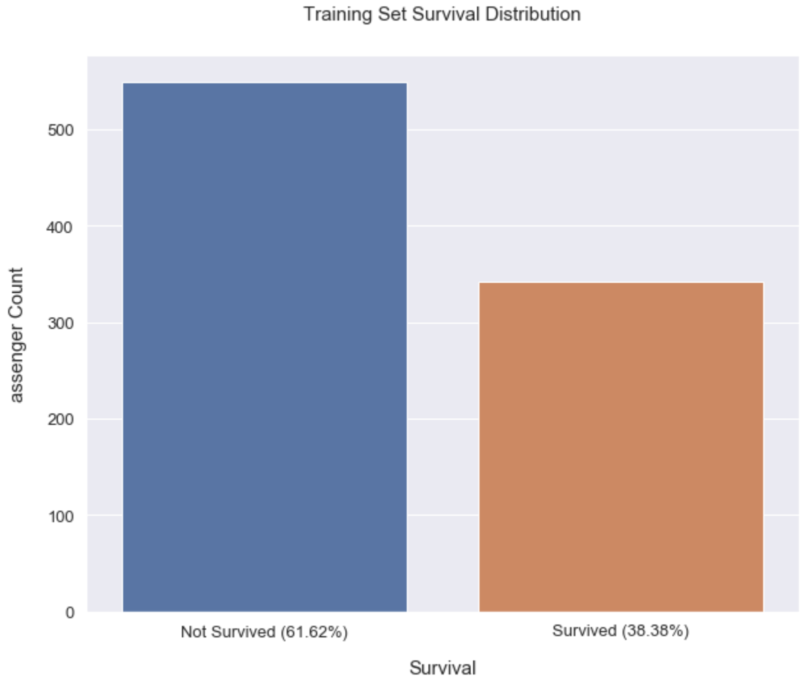
```
df_all.drop(['Cabin'], inplace=True, axis=1)

df_train, df_test = divide_df(df_all)
dfs = [df_train, df_test]

for df in dfs:
    display_missing(df)
```

```
Age column missing values: 0
Embarked column missing values: 0
Fare column missing values: 0
Name column missing values: 0
Parch column missing values: 0
PassengerId column missing values: 0
Pclass column missing values: 0
Sex column missing values: 0
SibSp column missing values: 0
Survived column missing values: 0
Ticket column missing values: 0
Deck column missing values: 0


Age column missing values: 0
Embarked column missing values: 0
Fare column missing values: 0
Name column missing values: 0
Parch column missing values: 0
PassengerId column missing values: 0
Pclass column missing values: 0
Sex column missing values: 0
SibSp column missing values: 0
Ticket column missing values: 0
Deck column missing values: 0
```

In [49]:

```
survived = df_train['Survived'].value_counts()[1]
not_survived = df_train['Survived'].value_counts()[0]
survived_per = survived / df_train.shape[0] * 100
not_survived_per = not_survived / df_train.shape[0] * 100

print('{} of {} passengers survived and it is the {:.2f}% of the training set.'.format(
survived, df_train.shape[0], survived_per))
print('{} of {} passengers didnt survive and it is the {:.2f}% of the training set.'.format(
not_survived, df_train.shape[0], not_survived_per))

plt.figure(figsize=(10, 8))
sns.countplot(df_train['Survived'])
plt.xlabel('Survival', size=15, labelpad=15)
plt.ylabel('assenger Count', size=15, labelpad=15)
plt.xticks((0,1), ['Not Survived ({0:.2f}%)'.format(not_survived_per),
                   'Survived ({0:.2f}%)'.format(survived_per)])
plt.tick_params(axis='x', labelsize=13)
plt.tick_params(axis='y', labelsize=13)

plt.title('Training Set Survival Distribution', size=15, y=1.05)

plt.show()
```

```
342 of 891 passengers survived and it is the 38.38% of the training set.
549 of 891 passengers didnt survive and it is the 61.62% of the training set.
```



In [50]:

```
df_train_corr = df_train.drop(
    ['PassengerId'], axis=1).corr().abs().unstack().sort_values(
    kind="quicksort", ascending=False).reset_index()
df_train_corr.rename(
    columns={"level_0": "Feature 1", "level_1": "Feature 2",
             0: 'Correlation Coefficient'}, inplace=True)
df_train_corr.drop(df_train_corr.iloc[1::2].index, inplace=True)
df_train_corr_nd = df_train_corr.drop(
    df_train_corr[
        df_train_corr['Correlation Coefficient'] == 1.0].index)

df_test_corr = df_test.corr().abs().unstack().sort_values(
    kind="quicksort", ascending=False).reset_index()
df_test_corr.rename(
    columns={"level_0": "Feature 1", "level_1": "Feature 2",
             0: 'Correlation Coefficient'}, inplace=True)
df_test_corr.drop(df_test_corr.iloc[1::2].index, inplace=True)
df_test_corr_nd = df_test_corr.drop(df_test_corr[
    df_test_corr['Correlation Coefficient'] == 1.0].index)
```

In [51]:

```
corr = df_train_corr_nd['Correlation Coefficient'] > 0.1
df_train_corr_nd[corr]
```

Out[51]:

	Feature 1	Feature 2	Correlation Coefficient
6	Pclass	Fare	0.549500
8	Pclass	Age	0.417667
10	SibSp	Parch	0.414838
12	Survived	Pclass	0.338481
14	Survived	Fare	0.257307
16	SibSp	Age	0.249747
18	Parch	Fare	0.216225
20	Age	Parch	0.176733
22	SibSp	Fare	0.159651
24	Age	Fare	0.124061

In [52]:

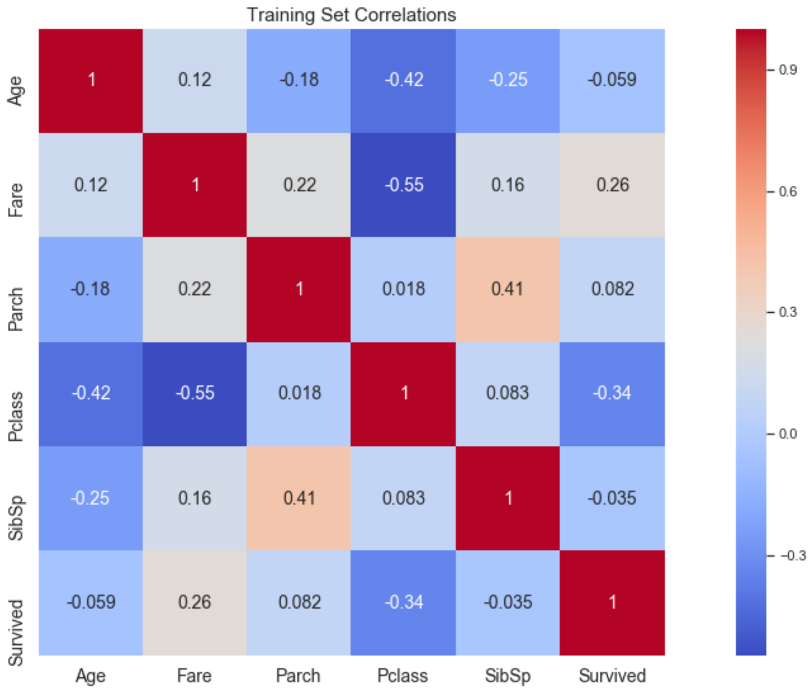
```
corr = df_test_corr_nd['Correlation Coefficient'] > 0.1
df_test_corr_nd[corr]
```

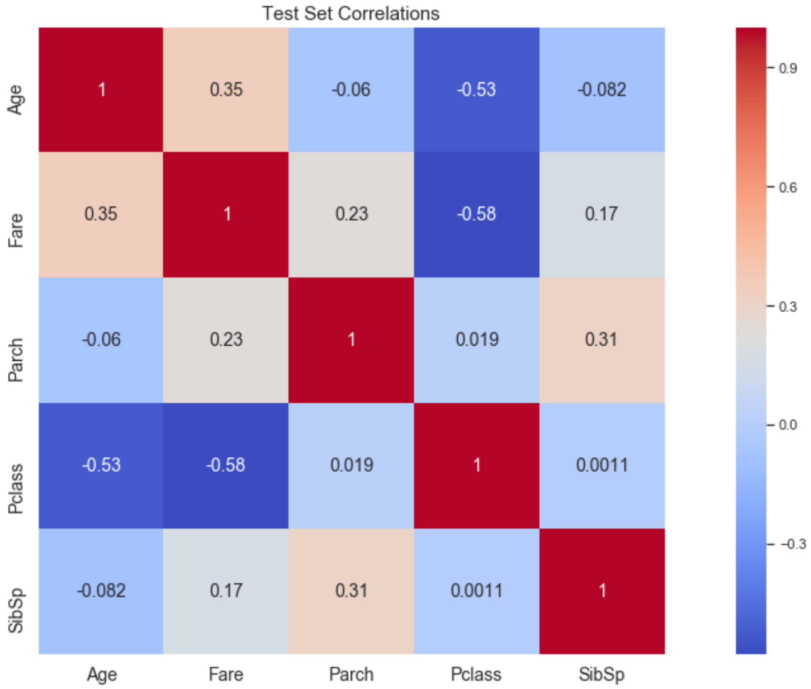
Out[52]:

	Feature 1	Feature 2	Correlation Coefficient
6	Fare	Pclass	0.577489
8	Age	Pclass	0.526789
10	Age	Fare	0.345347
12	SibSp	Parch	0.306895
14	Fare	Parch	0.230410
16	SibSp	Fare	0.172032

In [54]:

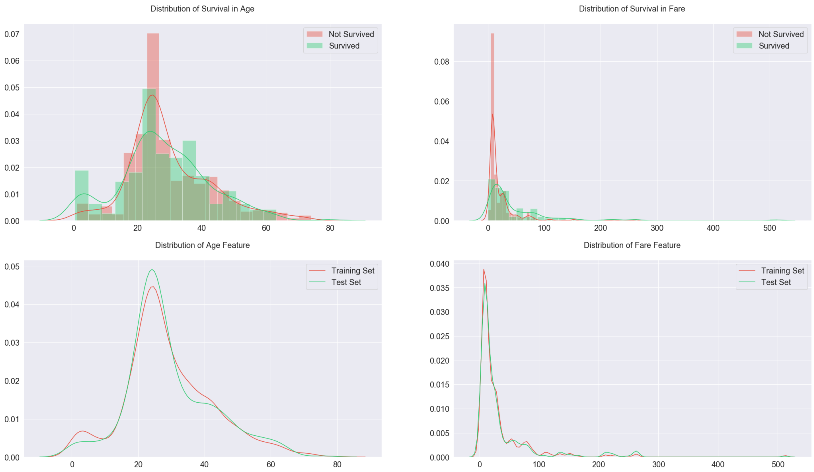
```
fig, axs = plt.subplots(nrows=2, figsize=(20,20))

sns.heatmap(df_train.drop(['PassengerId'], axis=1).corr(), ax=axs[0], annot=True,
           square=True, cmap='coolwarm', annot_kws={'size' : 14})

sns.heatmap(df_test.drop(['PassengerId'], axis=1).corr(), ax=axs[1], annot=True,
           square=True, cmap='coolwarm', annot_kws={'size' : 14})

for i in range(2):
    axs[i].tick_params(axis='x', labelsize=14)
    axs[i].tick_params(axis='y', labelsize=14)

axs[0].set_title('Training Set Correlations', size=15)
axs[1].set_title('Test Set Correlations', size=15)

plt.show()
```


Training Set Correlations


Test Set Correlations

In [55]:

```
cont_features = ['Age', 'Fare']
surv = df_train['Survived'] == 1

fig, axs = plt.subplots(ncols=2, nrows=2, figsize=(20, 20))
plt.subplots_adjust(right=1.5)

for i, feature in enumerate(cont_features):
    sns.distplot(df_train[~surv][feature],
                 label='Not Survived', hist=True, color='#e74c3c',
                 ax=axs[0][i])
    sns.distplot(df_train[surv][feature], label='Survived',
                 hist=True, color='#2ecc71', ax=axs[0][i])

    sns.distplot(df_train[feature], label='Training Set',
                 hist=False, color='#e74c3c', ax=axs[1][i])
    sns.distplot(df_test[feature], label='Test Set', hist=False,
                 color='#2ecc71', ax=axs[1][i])

    axs[0][i].set_xlabel('')
    axs[1][i].set_xlabel('')

    for j in range(2):
        axs[i][j].tick_params(axis='x', labelsize=20)
        axs[i][j].tick_params(axis='y', labelsize=20)

    axs[0][i].legend(loc='upper right', prop={'size': 20})
    axs[1][i].legend(loc='upper right', prop={'size': 20})
    axs[0][i].set_title('Distribution of Survival in {}'.format(feature),
                        size=20, y=1.05)

axs[1][0].set_title('Distribution of {} Feature'.format('Age'), size=20, y=1.05)
axs[1][1].set_title('Distribution of {} Feature'.format('Fare'),
                    size=20, y=1.05)

plt.show()
```



Distribution of Survival in Age

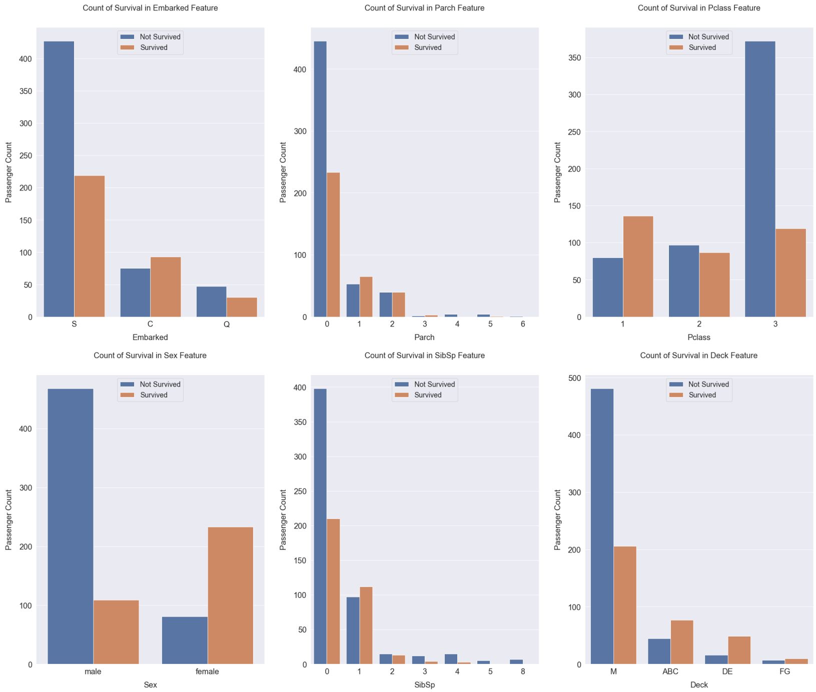
Distribution of Survival in Fare

Distribution of Age Feature

Distribution of Fare Feature

In [56]:

```
cat_features = ['Embarked', 'Parch', 'Pclass', 'Sex', 'SibSp', 'Deck']

fig, axs = plt.subplots(ncols=2, nrows=3, figsize=(20, 20))
plt.subplots_adjust(right=1.5, top=1.25)

for i, feature in enumerate(cat_features, 1):
    plt.subplot(2, 3, i)
    sns.countplot(x=feature, hue='Survived', data=df_train)

    plt.xlabel('{}'.format(feature), size=20, labelpad=15)
    plt.ylabel('Passenger Count', size=20, labelpad=15)
    plt.tick_params(axis='x', labelsize=20)
    plt.tick_params(axis='y', labelsize=20)

    plt.legend(['Not Survived', 'Survived'], loc='upper center',
               prop={'size': 18})
    plt.title('Count of Survival in {} Feature'.format(feature),
              size=20, y=1.05)

plt.show()
```



Count of Survival in Embarked Feature

Count of Survival in Parch Feature

Count of Survival in Pclass Feature

Count of Survival in Sex Feature

Count of Survival in SibSp Feature

Count of Survival in Deck Feature

In [57]:

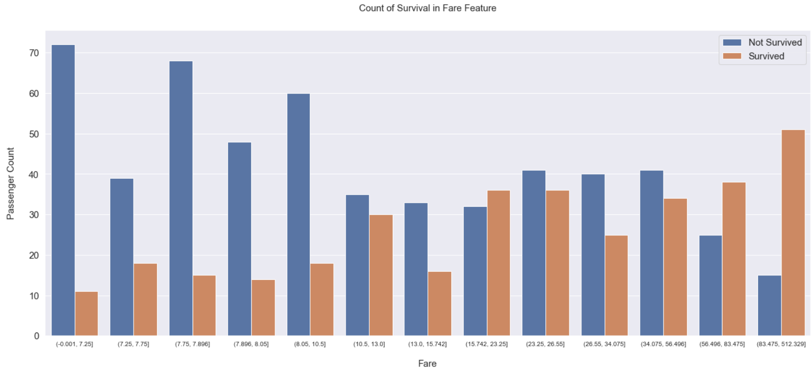
```
df_all = concat_df(df_train, df_test)
df_all.head()
```

Out[57]:

	Age	Deck	Embarked	Fare	Name	Parch	PassengerId	Pclass	Sex	SibSp	S
0	22.0	M	S	7.2500	Braund, Mr. Owen Harris	0	1	3	male	1	
1	38.0	ABC	C	71.2833	Cumings, Mrs. John Bradley (Florence Briggs Th...	0	2	1	female	1	
2	26.0	M	S	7.9250	Heikkinen, Miss. Laina	0	3	3	female	0	
3	35.0	ABC	S	53.1000	Futrelle, Mrs. Jacques Heath (Lily May Peel)	0	4	1	female	1	
4	35.0	M	S	8.0500	Allen, Mr. William Henry	0	5	3	male	0	

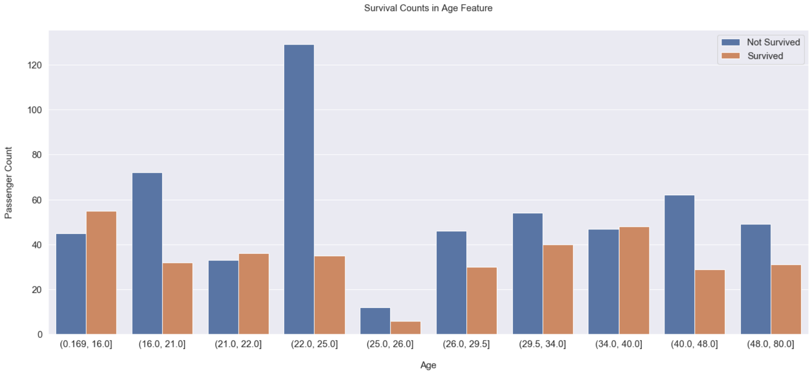
In [58]:

```
df_all['Fare'] = pd.qcut(df_all['Fare'], 13)

fig, axs = plt.subplots(figsize=(22, 9))
sns.countplot(x='Fare', hue='Survived', data=df_all)

plt.xlabel('Fare', size=15, labelpad=20)
plt.ylabel('Passenger Count', size=15, labelpad=20)
plt.tick_params(axis='x', labelsize=10)
plt.tick_params(axis='y', labelsize=15)

plt.legend(['Not Survived', 'Survived'], loc='upper right', prop={'size': 15})
plt.title('Count of Survival in {} Feature'.format('Fare'), size=15, y=1.05)

plt.show()
```



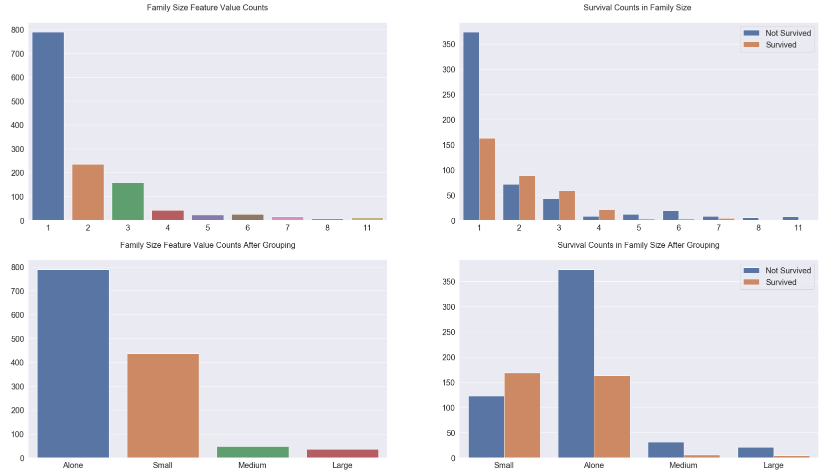
In [59]:

```
df_all['Age'] = pd.qcut(df_all['Age'], 10)

fig, axs = plt.subplots(figsize=(22, 9))
sns.countplot(x='Age', hue='Survived', data=df_all)

plt.xlabel('Age', size=15, labelpad=20)
plt.ylabel('Passenger Count', size=15, labelpad=20)
plt.tick_params(axis='x', labelsize=15)
plt.tick_params(axis='y', labelsize=15)

plt.legend(['Not Survived', 'Survived'], loc='upper right', prop={'size': 15})
plt.title('Survival Counts in {} Feature'.format('Age'), size=15, y=1.05)

plt.show()
```



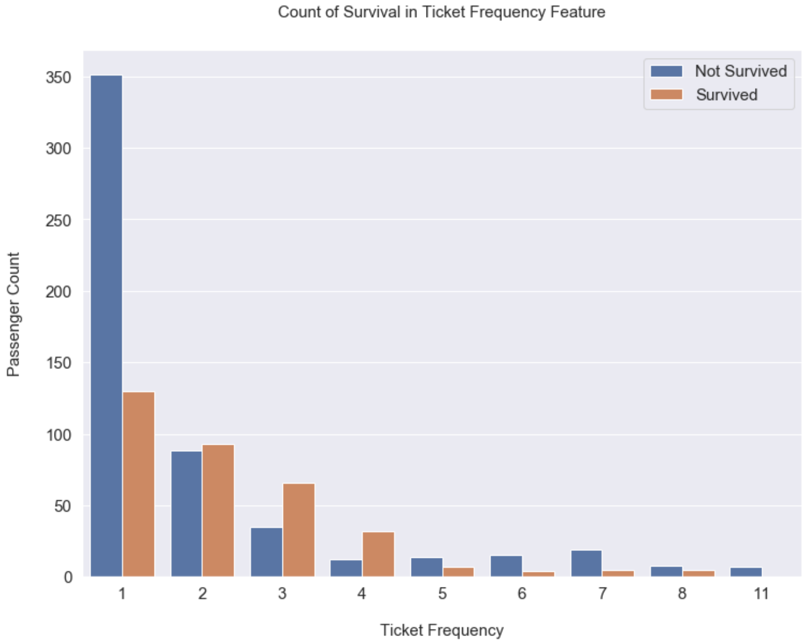
In [60]:

```
df_all['Family_Size'] = df_all['SibSp'] + df_all['Parch'] + 1

fig, axs = plt.subplots(figsize=(20, 20), ncols=2, nrows=2)
plt.subplots_adjust(right=1.5)

sns.barplot(x=df_all['Family_Size'].value_counts().index,
            y=df_all['Family_Size'].value_counts().values, ax=axs[0][0])
sns.countplot(x='Family_Size', hue='Survived', data=df_all, ax=axs[0][1])

axs[0][0].set_title('Family Size Feature Value Counts', size=20, y=1.05)
axs[0][1].set_title('Survival Counts in Family Size ', size=20, y=1.05)

family_map = {1: 'Alone', 2: 'Small', 3: 'Small', 4: 'Small', 5: 'Medium',
              6: 'Medium', 7: 'Large', 8: 'Large', 11: 'Large'}
df_all['Family_Size_Grouped'] = df_all['Family_Size'].map(family_map)

sns.barplot(x=df_all['Family_Size_Grouped'].value_counts().index,
            y=df_all['Family_Size_Grouped'].value_counts().values, ax=axs[1][0])
sns.countplot(x='Family_Size_Grouped', hue='Survived', data=df_all,
              ax=axs[1][1])

axs[1][0].set_title('Family Size Feature Value Counts After Grouping', size=20,
                    y=1.05)
axs[1][1].set_title('Survival Counts in Family Size After Grouping', size=20,
                    y=1.05)

for i in range(2):
    axs[i][1].legend(['Not Survived', 'Survived'], loc='upper right',
                     prop={'size': 20})
    for j in range(2):
        axs[i][j].tick_params(axis='x', labelsize=20)
        axs[i][j].tick_params(axis='y', labelsize=20)
        axs[i][j].set_xlabel('')
        axs[i][j].set_ylabel('')

plt.show()
```



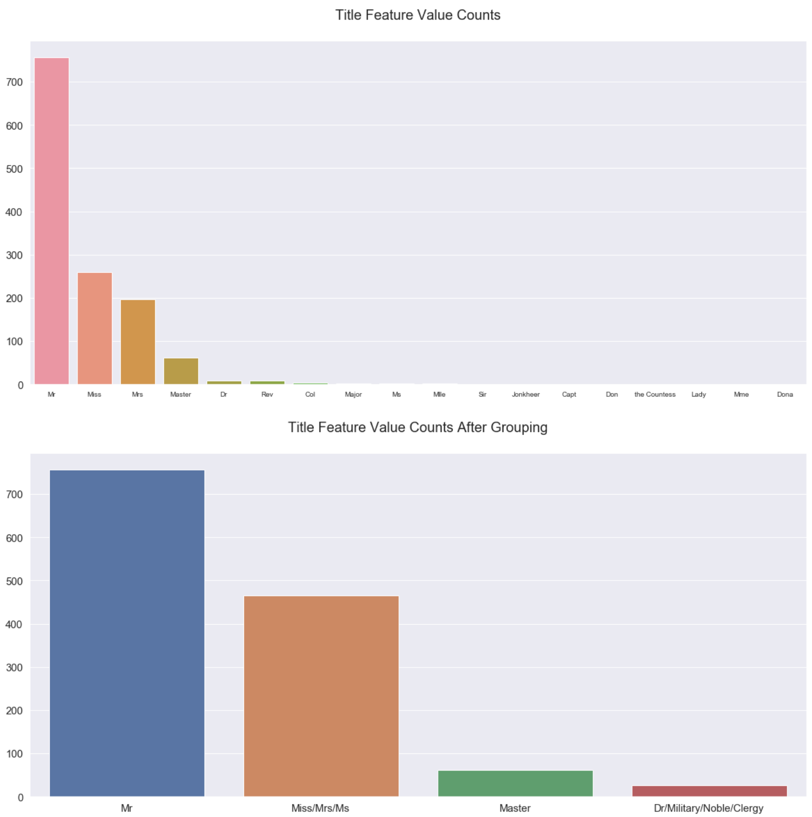
In [61]:

```
df_all['Ticket_Frequency'] = df_all.groupby('Ticket')['Ticket'].transform('count')

fig, axs = plt.subplots(figsize=(12, 9))
sns.countplot(x='Ticket_Frequency', hue='Survived', data=df_all)

plt.xlabel('Ticket Frequency', size=15, labelpad=20)
plt.ylabel('Passenger Count', size=15, labelpad=20)
plt.tick_params(axis='x', labelsize=15)
plt.tick_params(axis='y', labelsize=15)

plt.legend(['Not Survived', 'Survived'], loc='upper right', prop={'size': 15})
plt.title('Count of Survival in {} Feature'.format('Ticket Frequency'), size=15, y=1.05)

plt.show()
```



In [62]:

```
df_all['Title'] = df_all['Name'].str.split(', ', expand=True)[1].str.split('.', expand=True)[0]
df_all['Is_Married'] = 0
df_all['Is_Married'].loc[df_all['Title'] == 'Mrs'] = 1

fig, axs = plt.subplots(nrows=2, figsize=(20, 20))
sns.barplot(x=df_all['Title'].value_counts().index, y=df_all['Title'].value_counts().values, ax=
axs[0])

axs[0].tick_params(axis='x', labelsize=10)
axs[1].tick_params(axis='x', labelsize=15)

for i in range(2):
    axs[i].tick_params(axis='y', labelsize=15)

axs[0].set_title('Title Feature Value Counts', size=20, y=1.05)

df_all['Title'] = df_all['Title'].replace(['Miss', 'Mrs','Ms', 'Mlle', 'Lady', 'Mme', 'the Count
ess', 'Dona'], 'Miss/Mrs/Ms')
df_all['Title'] = df_all['Title'].replace(['Dr', 'Col', 'Major', 'Jonkheer', 'Capt', 'Sir', 'Do
n', 'Rev'], 'Dr/Military/Noble/Clergy')

sns.barplot(x=df_all['Title'].value_counts().index, y=df_all['Title'].value_counts().values, ax=
axs[1])
axs[1].set_title('Title Feature Value Counts After Grouping', size=20, y=1.05)

plt.show()
```



In [65]:

```
def extract_surname(data):
    families = []
    for i in range(len(data)):
        name = data.iloc[i]

        if '(' in name:
            name_no_bracket = name.split('(')[0]
        else:
            name_no_bracket = name

        family = name_no_bracket.split(',')[0]
        title = name_no_bracket.split(',')[1].strip().split(' ')[0]

        for c in string.punctuation:
            family = family.replace(c, '').strip()

        families.append(family)

    return families

df_all['Family'] = extract_surname(df_all['Name'])
df_train = df_all.loc[:890]
df_test = df_all.loc[891:]
dfs = [df_train, df_test]
```

In [68]:

```
non_unique_families = ₩
[x for x in df_train['Family'].unique() if x in df_test['Family'].unique()]
non_unique_tickets = ₩
[x for x in df_train['Ticket'].unique() if x in df_test['Ticket'].unique()]

df_family_survival_rate = ₩
df_train.groupby('Family')['Survived', 'Family','Family_Size'].median()
df_ticket_survival_rate = ₩
df_train.groupby('Ticket')['Survived', 'Ticket','Ticket_Frequency'].median()

family_rates = {}
ticket_rates = {}

for i in range(len(df_family_survival_rate)):
    if df_family_survival_rate.index[i] ₩
    in non_unique_families and df_family_survival_rate.iloc[i, 1] > 1:
        family_rates[df_family_survival_rate.index[i]] = ₩
        df_family_survival_rate.iloc[i, 0]

for i in range(len(df_ticket_survival_rate)):
    if df_ticket_survival_rate.index[i] ₩
    in non_unique_tickets and df_ticket_survival_rate.iloc[i, 1] > 1:
        ticket_rates[df_ticket_survival_rate.index[i]] = ₩
        df_ticket_survival_rate.iloc[i, 0]
```

In [69]:

```
mean_survival_rate = np.mean(df_train['Survived'])

train_family_survival_rate = []
train_family_survival_rate_NA = []
test_family_survival_rate = []
test_family_survival_rate_NA = []

for i in range(len(df_train)):
    if df_train['Family'][i] in family_rates:
        train_family_survival_rate.append(family_rates[df_train['Family'][i]])
        train_family_survival_rate_NA.append(1)
    else:
        train_family_survival_rate.append(mean_survival_rate)
        train_family_survival_rate_NA.append(0)

for i in range(len(df_test)):
    if df_test['Family'].iloc[i] in family_rates:
        test_family_survival_rate.append(family_rates[df_test['Family'].iloc[i]])
        test_family_survival_rate_NA.append(1)
    else:
        test_family_survival_rate.append(mean_survival_rate)
        test_family_survival_rate_NA.append(0)

df_train['Family_Survival_Rate'] = train_family_survival_rate
df_train['Family_Survival_Rate_NA'] = train_family_survival_rate_NA
df_test['Family_Survival_Rate'] = test_family_survival_rate
df_test['Family_Survival_Rate_NA'] = test_family_survival_rate_NA

train_ticket_survival_rate = []
train_ticket_survival_rate_NA = []
test_ticket_survival_rate = []
test_ticket_survival_rate_NA = []

for i in range(len(df_train)):
    if df_train['Ticket'][i] in ticket_rates:
        train_ticket_survival_rate.append(ticket_rates[df_train['Ticket'][i]])
        train_ticket_survival_rate_NA.append(1)
    else:
        train_ticket_survival_rate.append(mean_survival_rate)
        train_ticket_survival_rate_NA.append(0)

for i in range(len(df_test)):
    if df_test['Ticket'].iloc[i] in ticket_rates:
        test_ticket_survival_rate.append(ticket_rates[df_test['Ticket'].iloc[i]])
        test_ticket_survival_rate_NA.append(1)
    else:
        test_ticket_survival_rate.append(mean_survival_rate)
        test_ticket_survival_rate_NA.append(0)

df_train['Ticket_Survival_Rate'] = train_ticket_survival_rate
df_train['Ticket_Survival_Rate_NA'] = train_ticket_survival_rate_NA
df_test['Ticket_Survival_Rate'] = test_ticket_survival_rate
df_test['Ticket_Survival_Rate_NA'] = test_ticket_survival_rate_NA
```

In [70]:

```
for df in [df_train, df_test]:
    df['Survival_Rate'] = ₩
    (df['Ticket_Survival_Rate'] + df['Family_Survival_Rate']) / 2
    df['Survival_Rate_NA'] = ₩
    (df['Ticket_Survival_Rate_NA'] + df['Family_Survival_Rate_NA']) / 2
```

In [71]:

```
non_numeric_features = ₩
['Embarked', 'Sex', 'Deck', 'Title', 'Family_Size_Grouped', 'Age', 'Fare']

for df in dfs:
    for feature in non_numeric_features:
        df[feature] = LabelEncoder().fit_transform(df[feature])
```

In [72]:

```
cat_features = ['Pclass', 'Sex', 'Deck', 'Embarked', 'Title', 'Family_Size_Grouped']
encoded_features = []

for df in dfs:
    for feature in cat_features:
        encoded_feat = OneHotEncoder().fit_transform(
            df[feature].values.reshape(-1, 1)).toarray()
        n = df[feature].nunique()
        cols = ['{}_{}'.format(feature, n) for n in range(1, n + 1)]
        encoded_df = pd.DataFrame(encoded_feat, columns=cols)
        encoded_df.index = df.index
        encoded_features.append(encoded_df)

df_train = pd.concat([df_train, *encoded_features[:6]], axis=1)
df_test = pd.concat([df_test, *encoded_features[6:]], axis=1)
```

In [73]:

```
df_all = concat_df(df_train, df_test)
drop_cols = ['Deck', 'Embarked', 'Family', 'Family_Size', 'Family_Size_Grouped', 'Survived',
             'Name', 'Parch', 'PassengerId', 'Pclass', 'Sex', 'SibSp', 'Ticket', 'Title',
            'Ticket_Survival_Rate', 'Family_Survival_Rate', 'Ticket_Survival_Rate_NA', 'Family_S
urvival_Rate_NA']

df_all.drop(columns=drop_cols, inplace=True)

df_all.head()
```

Out[73]:

	Age	Deck_1	Deck_2	Deck_3	Deck_4	Embarked_1	Embarked_2	Embarked_3	Family_S
0	2	0.0	0.0	0.0	1.0	0.0	0.0	1.0	
1	7	1.0	0.0	0.0	0.0	1.0	0.0	0.0	
2	4	0.0	0.0	0.0	1.0	0.0	0.0	1.0	
3	7	1.0	0.0	0.0	0.0	0.0	0.0	1.0	
4	7	0.0	0.0	0.0	1.0	0.0	0.0	1.0	

5 rows × 26 columns

In [74]:

```
X_train = StandardScaler().fit_transform(df_train.drop(columns=drop_cols))
y_train = df_train['Survived'].values
X_test = StandardScaler().fit_transform(df_test.drop(columns=drop_cols))

print('X_train shape: {}'.format(X_train.shape))
print('y_train shape: {}'.format(y_train.shape))
print('X_test shape: {}'.format(X_test.shape))
```

```
X_train shape: (891, 26)
y_train shape: (891,)
X_test shape: (418, 26)
```

In [75]:

```
single_best_model = RandomForestClassifier(criterion='gini', n_estimators=1100,
                                           max_depth=5, min_samples_split=4,
                                           min_samples_leaf=5, max_features='auto',
                                           oob_score=True, random_state=SEED,
                                           n_jobs=1, verbose=1)

leaderboard_model = RandomForestClassifier(criterion='gini', n_estimators=1750,
                                           max_depth=7, min_samples_split=6,
                                           min_samples_leaf=6, max_features='auto',
                                           oob_score=True, random_state=SEED,
                                           n_jobs=1, verbose=1)
```

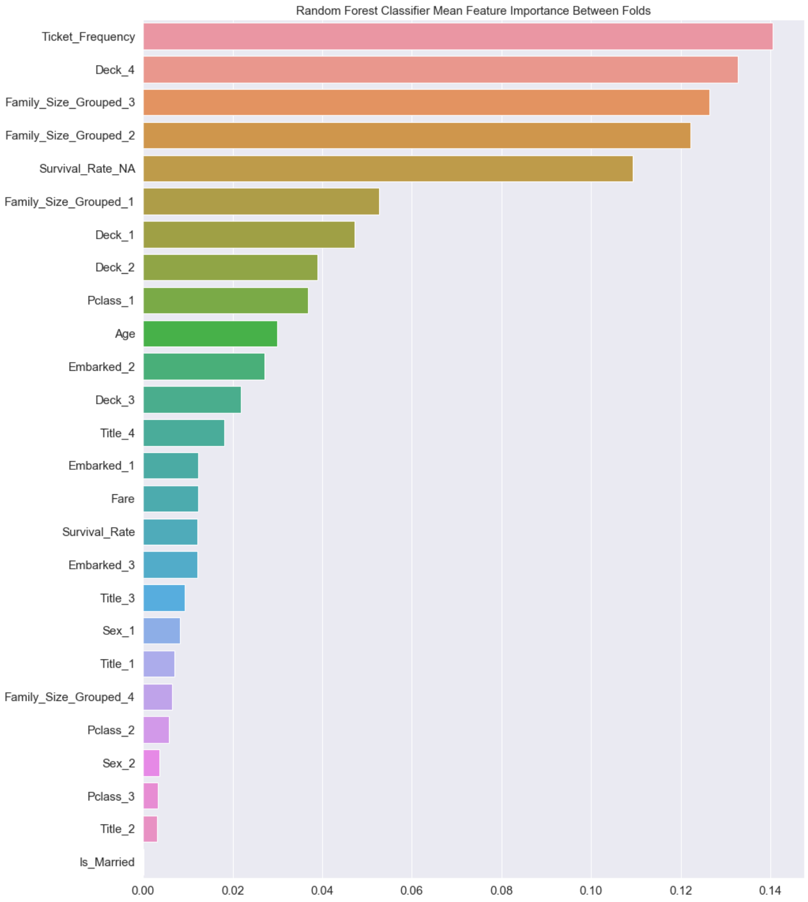
In [76]:

```
N = 5
oob = 0
probs = pd.DataFrame(np.zeros((len(X_test), N * 2)),
                     columns=['Fold_{}_Prob_{}'.format(i,j) for i in range(1, N + 1) ₩
                              for j in range(2)])
importances = pd.DataFrame(np.zeros((X_train.shape[1], N)), columns=['Fold_{}'.format(i) ₩
                                                                      for i in range(1, N + 1)],
index=df_all.columns)

fprs, tprs, scores = [], [], []

skf = StratifiedKFold(n_splits=N, random_state=N, shuffle=True)

for fold, (trn_idx, val_idx) in enumerate(skf.split(X_train, y_train), 1):
    print('Fold {}₩n'.format(fold))

    leaderboard_model.fit(X_train[trn_idx], y_train[trn_idx])

    trn_fpr, trn_tpr, trn_thresholds = roc_curve(y_train[trn_idx], leaderboard_model.predict_pro
ba(X_train[trn_idx])[:, 1])
    trn_auc_score = auc(trn_fpr, trn_tpr)

    val_fpr, val_tpr, val_thresholds = roc_curve(y_train[val_idx], leaderboard_model.predict_pro
ba(X_train[val_idx])[:, 1])
    val_auc_score = auc(val_fpr, val_tpr)

    scores.append((trn_auc_score, val_auc_score))
    fprs.append(val_fpr)
    tprs.append(val_tpr)

    probs.loc[:, 'Fold_{}_Prob_0'.format(fold)] = leaderboard_model.predict_proba(X_test)[:, 0]
    probs.loc[:, 'Fold_{}_Prob_1'.format(fold)] = leaderboard_model.predict_proba(X_test)[:, 1]
    importances.iloc[:, fold - 1] = leaderboard_model.feature_importances_

    oob += leaderboard_model.oob_score_ / N
    print('Fold {} OOB Score: {}₩n'.format(fold, leaderboard_model.oob_score_))

print('Average OOB Score: {}'.format(oob))
```

```
Fold 1


[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.6s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished

Fold 1 OOB Score: 0.8455056179775281

Fold 2


[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.6s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished


Fold 2 OOB Score: 0.8469101123595506

Fold 3


[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.6s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished

Fold 3 OOB Score: 0.8345021037868162

Fold 4


[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.6s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished

Fold 4 OOB Score: 0.8387096774193549

Fold 5


[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.6s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 1750 out of 1750 | elapsed:    0.1s finished

Fold 5 OOB Score: 0.8529411764705882

Average OOB Score: 0.8437137376027675
```

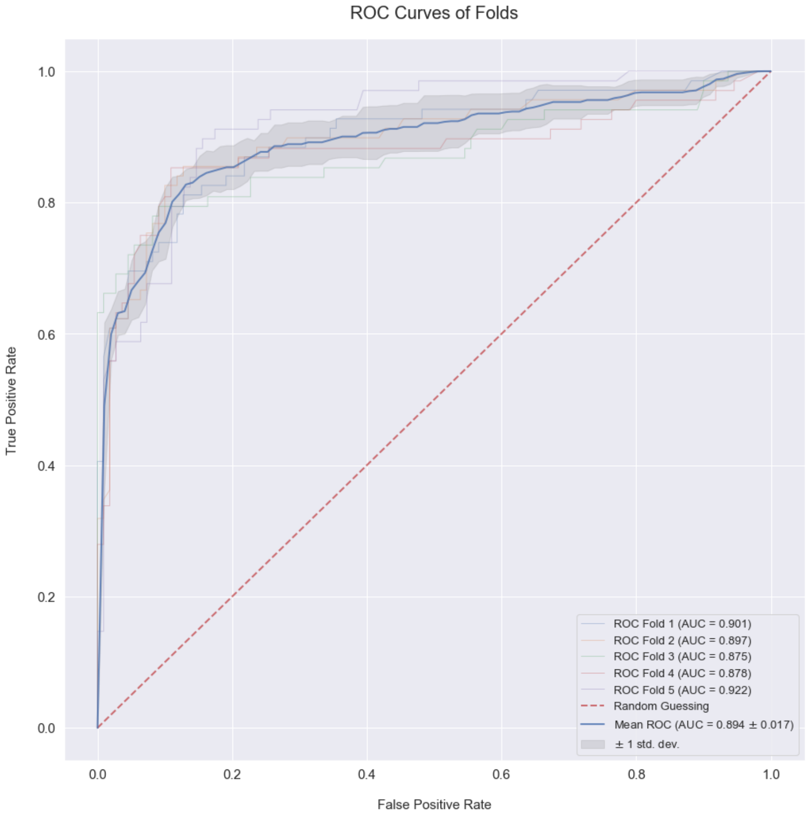
In [77]:

```
importances['Mean_Importance'] = importances.mean(axis=1)
importances.sort_values(by='Mean_Importance', inplace=True, ascending=False)

plt.figure(figsize=(15, 20))
sns.barplot(x='Mean_Importance', y=importances.index, data=importances)

plt.xlabel('')
plt.tick_params(axis='x', labelsize=15)
plt.tick_params(axis='y', labelsize=15)
plt.title('Random Forest Classifier Mean Feature Importance Between Folds', size=15)

plt.show()
```



In [78]:

```
def plot_roc_curve(fprs, tprs):

    tprs_interp = []
    aucs = []
    mean_fpr = np.linspace(0, 1, 100)
    f, ax = plt.subplots(figsize=(15, 15))

    for i, (fpr, tpr) in enumerate(zip(fprs, tprs), 1):
        tprs_interp.append(np.interp(mean_fpr, fpr, tpr))
        tprs_interp[-1][0] = 0.0
        roc_auc = auc(fpr, tpr)
        aucs.append(roc_auc)
        ax.plot(fpr, tpr, lw=1, alpha=0.3, label='ROC Fold {} (AUC = {:.3f})'.format(i, roc_auc
))

    plt.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r', alpha=0.8, label='Random Guessing'
)

    mean_tpr = np.mean(tprs_interp, axis=0)
    mean_tpr[-1] = 1.0
    mean_auc = auc(mean_fpr, mean_tpr)
    std_auc = np.std(aucs)

    ax.plot(mean_fpr, mean_tpr, color='b', label='Mean ROC (AUC = {:.3f} $₩pm$ {:.3f})'.format
(mean_auc, std_auc), lw=2, alpha=0.8)

    std_tpr = np.std(tprs_interp, axis=0)
    tprs_upper = np.minimum(mean_tpr + std_tpr, 1)
    tprs_lower = np.maximum(mean_tpr - std_tpr, 0)
    ax.fill_between(mean_fpr, tprs_lower, tprs_upper, color='grey', alpha=.2, label='$₩pm$ 1 st
d. dev.')

    ax.set_xlabel('False Positive Rate', size=15, labelpad=20)
    ax.set_ylabel('True Positive Rate', size=15, labelpad=20)
    ax.tick_params(axis='x', labelsize=15)
    ax.tick_params(axis='y', labelsize=15)
    ax.set_xlim([-0.05, 1.05])
    ax.set_ylim([-0.05, 1.05])

    ax.set_title('ROC Curves of Folds', size=20, y=1.02)
    ax.legend(loc='lower right', prop={'size': 13})

    plt.show()

plot_roc_curve(fprs, tprs)
```



In [83]:

```
class_survived = [col for col in probs.columns if col.endswith('Prob_1')]
probs['1'] = probs[class_survived].sum(axis=1) / N
probs['0'] = probs.drop(columns=class_survived).sum(axis=1) / N
probs['pred'] = 0
pos = probs[probs['1'] >= 0.5].index
probs.loc[pos, 'pred'] = 1

y_pred = probs['pred'].astype(int)
```

In [84]:

```
submission_df = pd.DataFrame(columns=['PassengerId', 'Survived'])
submission_df['PassengerId'] = df_test['PassengerId']
submission_df['Survived'] = y_pred.values
submission_df.to_csv('submissions.csv', header=True, index=False)
submission_df.head(10)
```

Out[84]:

	PassengerId	Survived
891	892	0
892	893	1
893	894	0
894	895	0
895	896	1
896	897	0
897	898	1
898	899	0
899	900	1
900	901	0

In [ ]: