



SpaceX Falcon 9 first stage Landing Prediction

Hands-on Lab: Complete the Data Collection API Lab

Estimated time needed: **45** minutes

In this capstone, we will predict if the Falcon 9 first stage will land successfully. SpaceX advertises Falcon 9 rocket launches on its website with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is because SpaceX can reuse the first stage. Therefore if we can determine if the first stage will land, we can determine the cost of a launch. This information can be used if an alternate company wants to bid against SpaceX for a rocket launch. In this lab, you will collect and make sure the data is in the correct format from an API. The following is an example of a successful and launch.



Several examples of an unsuccessful landing are shown here:



Most unsuccessful landings are planned. Space X performs a controlled landing in the oceans.

Objectives

In this lab, you will make a get request to the SpaceX API. You will also do some basic data wrangling and formating.

- Request to the SpaceX API
- Clean the requested data

Install the below libraries

```
In [2]: !pip install requests
!pip install pandas
!pip install numpy
```

Requirement already satisfied: requests in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (2.32.2)

Requirement already satisfied: charset-normalizer<4,>=2 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from requests) (3.4.1)

Requirement already satisfied: idna<4,>=2.5 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from requests) (3.10)

Requirement already satisfied: urllib3<3,>=1.21.1 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from requests) (2.3.0)

Requirement already satisfied: certifi>=2017.4.17 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from requests) (2025.1.31)

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Requirement already satisfied: numpy<2,>=1.26.0 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from pandas) (1.26.4)

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Requirement already satisfied: pytz>=2020.1 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from pandas) (2025.1)

Requirement already satisfied: tzdata>=2022.1 in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (from pandas) (2025.1)

Requirement already satisfied: six>=1.5 in /Users/kumararpit/Library/Python/3.12/lib/python/site-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)

Requirement already satisfied: numpy in /Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-packages (1.26.4)

Import Libraries and Define Auxiliary Functions

We will import the following libraries into the lab

```
In [3]: # Requests allows us to make HTTP requests which we will use to get
import requests
# Pandas is a software library written for the Python programming l
import pandas as pd
# NumPy is a library for the Python programming language, adding su
import numpy as np
# Datetime is a library that allows us to represent dates
import datetime

# Setting this option will print all columns of a dataframe
pd.set_option('display.max_columns', None)
# Setting this option will print all of the data in a feature
pd.set_option('display.max_colwidth', None)
```

Below we will define a series of helper functions that will help us use the API to extract information using identification numbers in the launch data.

From the `rocket` column we would like to learn the booster name.

```
In [4]: # Takes the dataset and uses the rocket column to call the API and
def getBoosterVersion(data):
    for x in data['rocket']:
        if x:
            response = requests.get("https://api.spacexdata.com/v4/rock
BoosterVersion.append(response['name'])
```

From the `launchpad` we would like to know the name of the launch site being used, the longitude, and the latitude.

```
In [5]: # Takes the dataset and uses the launchpad column to call the API a
def getLaunchSite(data):
    for x in data['launchpad']:
        if x:
            response = requests.get("https://api.spacexdata.com/v4/lau
Longitude.append(response['longitude'])
Latitude.append(response['latitude'])
LaunchSite.append(response['name'])
```

From the `payload` we would like to learn the mass of the payload and the orbit that it is going to.

```
In [6]: # Takes the dataset and uses the payloads column to call the API an
def getPayloadData(data):
    for load in data['payloads']:
        if load:
            response = requests.get("https://api.spacexdata.com/v4/payl
PayloadMass.append(response['mass_kg'])
Orbit.append(response['orbit'])
```

From `cores` we would like to learn the outcome of the landing, the type of the landing, number of flights with that core, whether gridfins were used, whether the core is reused, whether legs were used, the landing pad used, the block of the core which is a number used to separate version of cores, the number of times this specific core has been reused, and the serial of the core.

```
In [7]: # Takes the dataset and uses the cores column to call the API and a
def getCoreData(data):
    for core in data['cores']:
        if core['core'] != None:
            response = requests.get("https://api.spacexdata.com
Block.append(response['block'])
ReusedCount.append(response['reuse_count'])
Serial.append(response['serial'])
        else:
            Block.append(None)
            ReusedCount.append(None)
            Serial.append(None)
        Outcome.append(str(core['landing_success'])+' '+str(cor
Flights.append(core['flight'])
```

```
GridFins.append(core['gridfins'])
Reused.append(core['reused'])
Legs.append(core['legs'])
LandingPad.append(core['landpad'])
```

Now let's start requesting rocket launch data from SpaceX API with the following URL:

```
In [8]: spacex_url="https://api.spacexdata.com/v4/launches/past"
```

```
In [9]: response = requests.get(spacex_url)
```

Check the content of the response

```
In [ ]: print(response.content)
```

You should see the response contains massive information about SpaceX launches. Next, let's try to discover some more relevant information for this project.

Task 1: Request and parse the SpaceX launch data using the GET request

To make the requested JSON results more consistent, we will use the following static response object for this project:

```
In [11]: static_json_url='https://cf-courses-data.s3.us.cloud-object-storage'
```

We should see that the request was successful with the 200 status response code

```
In [12]: response.status_code
```

```
Out[12]: 200
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

```
In [13]: # Use json_normalize meethod to convert the json result into a data
json_data = response.json()
data = pd.json_normalize(json_data)
```

Using the dataframe `data` print the first 5 rows

```
In [14]: # Get the head of the dataframe
print(data.head())
```

	static_fire_date_utc	static_fire_date_unix	net	window	\
0	2006-03-17T00:00:00.000Z	1.142554e+09	False	0.0	

1	None	NaN	False	0.0
2	None	NaN	False	0.0
3	2008-09-20T00:00:00.000Z	1.221869e+09	False	0.0
4	None	NaN	False	0.0

	rocket	success	\
0	5e9d0d95eda69955f709d1eb	False	
1	5e9d0d95eda69955f709d1eb	False	
2	5e9d0d95eda69955f709d1eb	False	
3	5e9d0d95eda69955f709d1eb	True	
4	5e9d0d95eda69955f709d1eb	True	

```
failures \
0          [{'time': 33, 'altitude': None, 'reason': 'merlin engine failure'}]
1          [{'time': 301, 'altitude': 289, 'reason': 'harmonic oscillation leading to premature engine shutdown'}]
2          [{'time': 140, 'altitude': 35, 'reason': 'residual stage-1 thrust led to collision between stage 1 and stage 2'}]
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```

2	5e9e4502f5090995de566f86	3	Trailblazer
3	5e9e4502f5090995de566f86	4	RatSat
4	5e9e4502f5090995de566f86	5	RazakSat

	date_utc	date_unix	date_local
\			
0	2006-03-24T22:30:00.000Z	1143239400	2006-03-25T10:30:00+12:00
1	2007-03-21T01:10:00.000Z	1174439400	2007-03-21T13:10:00+12:00
2	2008-08-03T03:34:00.000Z	1217734440	2008-08-03T15:34:00+12:00
3	2008-09-28T23:15:00.000Z	1222643700	2008-09-28T11:15:00+12:00
4	2009-07-13T03:35:00.000Z	1247456100	2009-07-13T15:35:00+12:00

	date_precision	upcoming	\
0	hour	False	
1	hour	False	
2	hour	False	
3	hour	False	
4	hour	False	

```
cores \
0 [{'core': '5e9e289df35918033d3b2623', 'flight': 1, 'gridfins': False, 'legs': False, 'reused': False, 'landing_attempt': False, 'landing_success': None, 'landing_type': None, 'landpad': None}]
1 [{'core': '5e9e289ef35918416a3b2624', 'flight': 1, 'gridfins': False, 'legs': False, 'reused': False, 'landing_attempt': False, 'landing_success': None, 'landing_type': None, 'landpad': None}]
2 [{'core': '5e9e289ef3591814873b2625', 'flight': 1, 'gridfins': False, 'legs': False, 'reused': False, 'landing_attempt': False, 'landing_success': None, 'landing_type': None, 'landpad': None}]
3 [{'core': '5e9e289ef3591855dc3b2626', 'flight': 1, 'gridfins': False, 'legs': False, 'reused': False, 'landing_attempt': False, 'landing_success': None, 'landing_type': None, 'landpad': None}]
4 [{'core': '5e9e289ef359184f103b2627', 'flight': 1, 'gridfins': False, 'legs': False, 'reused': False, 'landing_attempt': False, 'landing_success': None, 'landing_type': None, 'landpad': None}]
```

	auto_update	tbd	launch_library_id	id	\
0	True	False	None	5eb87cd9ffd86e000604b32a	
1	True	False	None	5eb87cdaffd86e000604b32b	
2	True	False	None	5eb87cdbffd86e000604b32c	
3	True	False	None	5eb87cdbffd86e000604b32d	
4	True	False	None	5eb87cdcffd86e000604b32e	

	fairings.reused	fairings.recovery_attempt	fairings.recovered	fairings.ships	\
0	False	False	False		
1	False	False	False		
2	False	False	False		
3	False	False	False		
4	False	False	False		

```

links.patch.small \
0 https://images2.imgbox.com/94/f2/NN6Ph45r_o.png
1 https://images2.imgbox.com/f9/4a/ZboXReNb_o.png
2 https://images2.imgbox.com/6c/cb/na1tzhHs_o.png
3 https://images2.imgbox.com/95/39/sRqN7rsv_o.png
4 https://images2.imgbox.com/ab/5a/Pequxd5d_o.png

```

```

links.patch.large links.reddit.camp
align \
0 https://images2.imgbox.com/5b/02/QcxHUb5V_o.png
None
1 https://images2.imgbox.com/80/a2/bkWotCIS_o.png
None
2 https://images2.imgbox.com/4a/80/k1oAkY0k_o.png
None
3 https://images2.imgbox.com/a3/99/qswRYzE8_o.png
None
4 https://images2.imgbox.com/92/e4/7Cf6MLY0_o.png
None

```

```

links.reddit.launch links.reddit.media links.reddit.recovery \
0 None None None
1 None None None
2 None None None
3 None None None
4 None None None

```

```

links.flickr.small links.flickr.original \
0 [] []
1 [] []
2 [] []
3 [] []
4 [] []

```

```

links.presskit \
0
None
1
None
2
None
3
None
4 http://www.spacex.com/press/2012/12/19/spacexs-falcon-1-successfu
lly-delivers-razaksat-satellite-orbit

```

```

links.webcast links.youtube_id \
0 https://www.youtube.com/watch?v=0a_00nJ_Y88 0a_00nJ_Y88
1 https://www.youtube.com/watch?v=Lk4zQ2wP-Nc Lk4zQ2wP-Nc
2 https://www.youtube.com/watch?v=v0w9p3U8860 v0w9p3U8860
3 https://www.youtube.com/watch?v=dLQ2tZEH6G0 dLQ2tZEH6G0
4 https://www.youtube.com/watch?v=yTaIDooc80g yTaIDooc80g

```

li


```

nks.article \
0 https://www.space.com/2196-spacex-inaugural-falcon-1-rocket-lost-launch.html
1 https://www.space.com/3590-spacex-falcon-1-rocket-fails-reach-orbit.html
2 http://www.spacex.com/news/2013/02/11/falcon-1-flight-3-mission-summary
3 https://en.wikipedia.org/wiki/Ratsat
4 http://www.spacex.com/news/2013/02/12/falcon-1-flight-5

```

	links.wikipedia	fairings
0	https://en.wikipedia.org/wiki/DemoSat	NaN
1	https://en.wikipedia.org/wiki/DemoSat	NaN
2	https://en.wikipedia.org/wiki/Trailblazer_(satellite)	NaN
3	https://en.wikipedia.org/wiki/Ratsat	NaN
4	https://en.wikipedia.org/wiki/RazakSAT	NaN

You will notice that a lot of the data are IDs. For example the rocket column has no information about the rocket just an identification number.

We will now use the API again to get information about the launches using the IDs given for each launch. Specifically we will be using columns `rocket`, `payloads`, `launchpad`, and `cores`.

```

In [15]: # Lets take a subset of our dataframe keeping only the features we
data = data[['rocket', 'payloads', 'launchpad', 'cores', 'flight_nu

# We will remove rows with multiple cores because those are falcon
data = data[data['cores'].map(len)==1]
data = data[data['payloads'].map(len)==1]

# Since payloads and cores are lists of size 1 we will also extract
data['cores'] = data['cores'].map(lambda x : x[0])
data['payloads'] = data['payloads'].map(lambda x : x[0])

# We also want to convert the date_utc to a datetime datatype and t
data['date'] = pd.to_datetime(data['date_utc']).dt.date

# Using the date we will restrict the dates of the launches
data = data[data['date'] <= datetime.date(2020, 11, 13)]

```

- From the `rocket` we would like to learn the booster name
- From the `payload` we would like to learn the mass of the payload and the orbit that it is going to
- From the `launchpad` we would like to know the name of the launch site being used, the longitude, and the latitude.
- From `cores` we would like to learn the outcome of the landing, the

type of the landing, number of flights with that core, whether gridfins were used, whether the core is reused, whether legs were used, the landing pad used, the block of the core which is a number used to separate version of cores, the number of times this specific core has been reused, and the serial of the core.

The data from these requests will be stored in lists and will be used to create a new dataframe.

```
In [16]: #Global variables
BoosterVersion = []
PayloadMass = []
Orbit = []
LaunchSite = []
Outcome = []
Flights = []
GridFins = []
Reused = []
Legs = []
LandingPad = []
Block = []
ReusedCount = []
Serial = []
Longitude = []
Latitude = []
```

These functions will apply the outputs globally to the above variables. Let's take a look at `BoosterVersion` variable. Before we apply `getBoosterVersion` the list is empty:

```
In [17]: BoosterVersion
```

```
Out[17]: []
```

Now, let's apply `getBoosterVersion` function method to get the booster version

```
In [18]: # Call getBoosterVersion
getBoosterVersion(data)
```

the list has now been update

```
In [19]: BoosterVersion[0:5]
```

```
Out[19]: ['Falcon 1', 'Falcon 1', 'Falcon 1', 'Falcon 1', 'Falcon 9']
```

we can apply the rest of the functions here:

```
In [20]: # Call getLaunchSite
getLaunchSite(data)
```

```
In [21]: # Call getPayloadData
getPayloadData(data)
```

```
In [22]: # Call getCoreData
getCoreData(data)
```

Finally lets construct our dataset using the data we have obtained. We we combine the columns into a dictionary.

```
In [23]: launch_dict = {'FlightNumber': list(data['flight_number']),
                        'Date': list(data['date']),
                        'BoosterVersion':BoosterVersion,
                        'PayloadMass':PayloadMass,
                        'Orbit':Orbit,
                        'LaunchSite':LaunchSite,
                        'Outcome':Outcome,
                        'Flights':Flights,
                        'GridFins':GridFins,
                        'Reused':Reused,
                        'Legs':Legs,
                        'LandingPad':LandingPad,
                        'Block':Block,
                        'ReusedCount':ReusedCount,
                        'Serial':Serial,
                        'Longitude': Longitude,
                        'Latitude': Latitude}
```

Then, we need to create a Pandas data frame from the dictionary launch_dict.

```
In [24]: # Create a data from launch_dict
launch_df = pd.DataFrame(launch_dict)
```

Show the summary of the dataframe

```
In [25]: # Show the head of the dataframe
print(launch_df.head())
```

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	\
0	1	2006-03-24	Falcon 1	20.0	LEO	
1	2	2007-03-21	Falcon 1	NaN	LEO	
2	4	2008-09-28	Falcon 1	165.0	LEO	
3	5	2009-07-13	Falcon 1	200.0	LEO	
4	6	2010-06-04	Falcon 9	NaN	LEO	

	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	Land
ingPad \							
0	Kwajalein Atoll	None	None	1	False	False	False
None							
1	Kwajalein Atoll	None	None	1	False	False	False
None							
2	Kwajalein Atoll	None	None	1	False	False	False
None							
3	Kwajalein Atoll	None	None	1	False	False	False
None							
4	CCSFS SLC 40	None	None	1	False	False	False
None							

	Block	ReusedCount	Serial	Longitude	Latitude
0	NaN	0	Merlin1A	167.743129	9.047721
1	NaN	0	Merlin2A	167.743129	9.047721
2	NaN	0	Merlin2C	167.743129	9.047721
3	NaN	0	Merlin3C	167.743129	9.047721
4	1.0	0	B0003	-80.577366	28.561857

Task 2: Filter the dataframe to only include Falcon 9 launches

Finally we will remove the Falcon 1 launches keeping only the Falcon 9 launches. Filter the data dataframe using the `BoosterVersion` column to only keep the Falcon 9 launches. Save the filtered data to a new dataframe called `data_falcon9`.

```
In [26]: # Hint data['BoosterVersion']!='Falcon 1'
data_falcon9 = launch_df[launch_df['BoosterVersion'] != 'Falcon 1']
print(data_falcon9.head())
```

FlightNumber		Date	BoosterVersion	PayloadMass	Orbit	Lau
nchSite \						
4	6	2010-06-04	Falcon 9	NaN	LEO	CCSFS
SLC 40						
5	8	2012-05-22	Falcon 9	525.0	LEO	CCSFS
SLC 40						
6	10	2013-03-01	Falcon 9	677.0	ISS	CCSFS
SLC 40						
7	11	2013-09-29	Falcon 9	500.0	P0	VAFB
SLC 4E						
8	12	2013-12-03	Falcon 9	3170.0	GT0	CCSFS
SLC 40						

	Outcome		Flights	GridFins	Reused	Legs	LandingPad	Block
\								
4	None	None	1	False	False	False	None	1.0
5	None	None	1	False	False	False	None	1.0
6	None	None	1	False	False	False	None	1.0
7	False	Ocean	1	False	False	False	None	1.0
8	None	None	1	False	False	False	None	1.0

	ReusedCount	Serial	Longitude	Latitude
4	0	B0003	-80.577366	28.561857
5	0	B0005	-80.577366	28.561857
6	0	B0007	-80.577366	28.561857
7	0	B1003	-120.610829	34.632093
8	0	B1004	-80.577366	28.561857

Now that we have removed some values we should reset the FlightNumber column

```
In [27]: data_falcon9.loc[:, 'FlightNumber'] = list(range(1, data_falcon9.shape[0] + 1))
```

Out[27]:

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite
4	1	2010-06-04	Falcon 9	NaN	LEO	CCSFS SLC 40
5	2	2012-05-22	Falcon 9	525.0	LEO	CCSFS SLC 40
6	3	2013-03-01	Falcon 9	677.0	ISS	CCSFS SLC 40
7	4	2013-09-29	Falcon 9	500.0	PO	VAFB SLC 4E
8	5	2013-12-03	Falcon 9	3170.0	GTO	CCSFS SLC 40
...
89	86	2020-09-03	Falcon 9	15600.0	VLEO	KSC LC 39A
90	87	2020-10-06	Falcon 9	15600.0	VLEO	KSC LC 39A
91	88	2020-10-18	Falcon 9	15600.0	VLEO	KSC LC 39A
92	89	2020-10-24	Falcon 9	15600.0	VLEO	CCSFS SLC 40
93	90	2020-11-05	Falcon 9	3681.0	MEO	CCSFS SLC 40

90 rows × 7 columns

Data Wrangling

We can see below that some of the rows are missing values in our dataset.

```
In [28]: data_falcon9.isnull().sum()
```

```
Out[28]: FlightNumber      0
         Date              0
         BoosterVersion    0
         PayloadMass       5
         Orbit             0
         LaunchSite        0
         Outcome           0
         Flights           0
         GridFins          0
         Reused            0
         Legs              0
         LandingPad        26
         Block             0
         ReusedCount       0
         Serial            0
         Longitude         0
         Latitude          0
         dtype: int64
```

Before we can continue we must deal with these missing values. The `LandingPad` column will retain None values to represent when landing pads were not used.

Task 3: Dealing with Missing Values

Calculate below the mean for the `PayloadMass` using the `.mean()`. Then use the mean and the `.replace()` function to replace `np.nan` values in the data with the mean you calculated.

```
In [29]: # Calculate the mean value of PayloadMass column
         payload_mean = data_falcon9['PayloadMass'].mean()
         # Replace the np.nan values with its mean value
         data_falcon9['PayloadMass'] = data_falcon9['PayloadMass'].replace(n
         print(data_falcon9.isnull().sum())
```

```
FlightNumber      0
Date              0
BoosterVersion    0
PayloadMass       0
Orbit             0
LaunchSite        0
Outcome           0
Flights           0
GridFins          0
Reused            0
Legs              0
LandingPad        26
Block             0
ReusedCount       0
Serial            0
Longitude         0
Latitude          0
dtype: int64
```

```
/var/folders/7q/_y8rd1ld4kd18vhknhrvts9r0000gn/T/ipykernel_24115/2093524461.py:4: SettingWithCopyWarning:  
A value is trying to be set on a copy of a slice from a DataFrame.  
Try using .loc[row_indexer,col_indexer] = value instead  
  
See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user\_guide/indexing.html#returning-a-view-versus-a-copy  
    data_falcon9['PayloadMass'] = data_falcon9['PayloadMass'].replace(  
        np.nan, payload_mean)
```

You should see the number of missing values of the `PayloadMass` change to zero.

Now we should have no missing values in our dataset except for in `LandingPad`.

We can now export it to a **CSV** for the next section, but to make the answers consistent, in the next lab we will provide data in a pre-selected date range.

```
data_falcon9.to_csv('dataset_part_1.csv', index=False)
```

```
In [30]: data_falcon9.to_csv('dataset_part_1.csv', index=False)
```

Authors

[Joseph Santarcangelo](#) has a PhD in Electrical Engineering, his research focused on using machine learning, signal processing, and computer vision to determine how videos impact human cognition. Joseph has been working for IBM since he completed his PhD.

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