Topic	DATA SCIENCE - 3	
Class Description	**The student will be applying Machine Learning algorithms and statistics to filter out more planets. Students will be exploring new scientific facts.**	
Class	**PRO C133**	
Class time	**45 mins**	
Goal	• Plot various charts on data • Filter out more planets • Learning about calculating the speed of a planet	

Resources Required	• Teacher Resources:
	  ○ Laptop with internet connectivity
	  ○ Earphones with mic
	  ○ Notebook and pen
	  ○ Smartphone
	• Student Resources:
	  ○ Laptop with internet connectivity
	  ○ Earphones with mic
	  ○ Notebook and pen	

Class structure	**Warm-Up** **Teacher-Led Activity 1** **Student-Led Activity 1** **Wrap-Up**	**5 mins** **15 mins** **20 mins** **05 mins**
Credit & Permissions:	**Exoplanet Exploration by NASA**	
WARM-UP SESSION - 10 mins		
Teacher Starts Slideshow **Slide # to #** 		

<table>
<tr><td colspan="2"><Note: Only Applicable for Classes with VA>
Refer to speaker notes and follow the instructions on each slide.</td></tr>
<tr><td>Teacher Action</td><td>Student Action</td></tr>
<tr><td>Hey <student's name>. How are you? It’s great to see you!
Are you excited to learn something new today?

Following are the WARM-UP session deliverables:
● Greet the student.
● Revision of previous class activities.
● Quizzes.</td><td>ESR: Hi, thanks!
Yes, I am excited about it!

Click on the slide show tab and present the slides</td></tr>
<tr><td colspan="2">WARM-UP QUIZ
Click on In-Class Quiz</td></tr>
<tr><td colspan="2">Continue WARM-UP Session
Slide # to #
<Note: Only Applicable for Classes with VA></td></tr>
<tr><td colspan="2">Activity Details

Following are the session deliverables:
● Appreciate the student.
● Narrate the story by using hand gestures and voice modulation methods to bring in more interest in students.</td></tr>
<tr><td>Teacher Action</td><td>Student Action</td></tr>
<tr><td>In the last class, we explored the different types of planets and filtered out more planets based on that.

Can you name the different types of planets?</td><td>

ESR:
- Terrestrial
- Super-Earth
- Neptune Like</td></tr>
</table>

Great! Now in today's class, we will check one more factor i.e. the speed of a planet. This is important for our survival. So let's filter out more planets where we wouldn't survive!	- Gas Giant
Teacher Ends Slideshow 	
TEACHER-LED ACTIVITY - 10 mins	
Teacher Initiates Screen Share	
ACTIVITY • **To calculate the speed of a planet** • **Filtering out more planets** • **Plotting data**	
Teacher Action	**Student Action**
Note: *Open Teacher Activity 1 for the boilerplate code. It is the same code that we did in the previous class.* Let's check the headers that we have in the dataset.	
`print(headers)` `['row_num', 'name', 'light_years_from_earth', 'planet_mass', 'stellar_magnitude', 'discovery_date', 'planet_type', 'planet_radius', 'orbital_radius', 'orbital_period',`	
Here, we see two headers! **orbital_radius** and **orbital_period**. The **orbital radius** is the distance of the planet from the host star. The **orbital period** is the time the planet takes to complete one orbit around its host star.	

Let's plot a scatter plot to see how these values are for all the planets we are left with (**suitable_planets list**).

Before we plot a scatter plot though, we can see that the **orbital_radius (9th column)** has a strange value AU(Astronomical Unit) and the **orbital_period (10th column)** is in days or years!

Let's understand what AU is first and then we will also have to fix these values in order to perform statistics and plot data.

AU is a short form of Astronomical Unit. 1 AU is roughly the distance between the Sun and the Earth.

1 AU is approximately **150 million kilometers.**

We can go with the AU value but for the orbital period, we need to ensure that all the values are with respect to days. This means that the columns that have **years** notation should be converted into **days** by multiplying it with 365 (The number of days we have in a year).

Let's start coding.
We also have a few unknown values for the planet's orbital radius and we need to remove those rows as well!

1. Create a temporary list because we want to remove the planets for whom we do not know the orbital radius.
2. Use **for** loop, where we are checking if the value was unknown and if it is, we are removing the element from our list of suitable planets.

```
temp_suitable_planets = list(suitable_planets)
for planet_data in temp_suitable_planets:
  if planet_data[8].lower() == "unknown":
    suitable_planets.remove(planet_data)
```

3. Next, convert all the years and days to **days** and in **float** values.

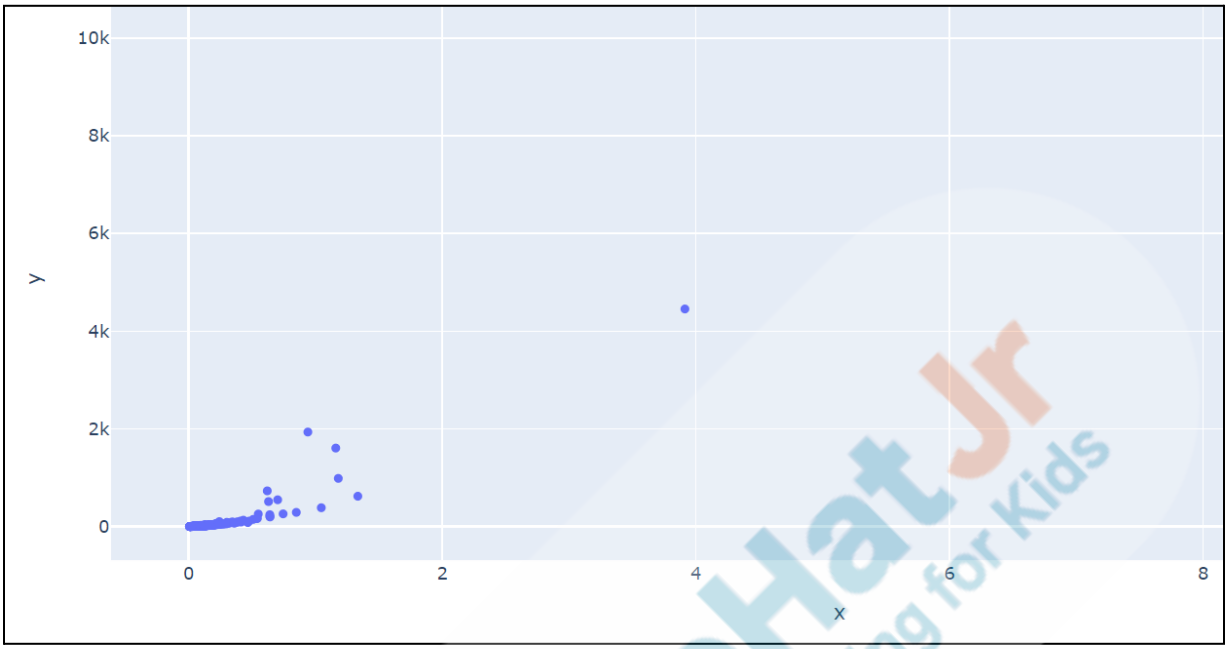
4. Use the **split()** method. The **split()** method separates the string depending upon the separator and returns the string in the form of a list.
5. For example, the string is 326 days and after the split operation we get ['326', 'days']. Thus the number of the days is at index number **0**. This is then converted into float.
6. Similarly, years are converted into days by multiplying them with 365. For maintaining uniformity we are then converting them into days as well.
7. Also, convert the astronomical units of orbital radius into floats.

```
temp_suitable_planets = list(suitable_planets)
for planet_data in temp_suitable_planets:
  if planet_data[8].lower() == "unknown":
    suitable_planets.remove(planet_data)

for planet_data in suitable_planets:
  if planet_data[9].split(" ")[1].lower() == "days":
    planet_data[9] = float(planet_data[9].split(" ")[0])        #Days
  else:
    planet_data[9] = float(planet_data[9].split(" ")[0])*365    #Convert Years into Days

  planet_data[8] = float(planet_data[8].split(" ")[0])
```

8. Finally, segregate the orbital period and radius for all the planets and plotting a scatter plot with radius on the X-coordinate and period on the Y-coordinate.

```
temp_suitable_planets = list(suitable_planets)
for planet_data in temp_suitable_planets:
  if planet_data[8].lower() == "unknown":
    suitable_planets.remove(planet_data)

for planet_data in suitable_planets:
  if planet_data[9].split(" ")[1].lower() == "days":
    planet_data[9] = float(planet_data[9].split(" ")[0])
  else:
    planet_data[9] = float(planet_data[9].split(" ")[0])*365

  planet_data[8] = float(planet_data[8].split(" ")[0])

orbital_radiuses = []
orbital_periods = []
for planet_data in suitable_planets:
  orbital_radiuses.append(planet_data[8])
  orbital_periods.append(planet_data[9])

fig = px.scatter(x=orbital_radiuses, y=orbital_periods)
fig.show()
```

9. Run the code and check the scatter plot.



Here, we can see that most of the suitable planets lie within 2 astronomical units, which is great!

Let's understand a few facts now:

1. If a planet is too close to its sun, we can say that the planet will be too hot for us to survive.
2. If a planet is too far away from its sun, we can say that the planet will be too cold for us to survive.

We call this the **Goldilocks Zone.** Goldilocks Zone is the habitable zone where the planet is more likely to have just the right conditions to sustain life.

For us, we are at the very beginning of the Goldilock Zone whereas Mars is at the end of it.

Earth is 1AU from the Sun and Mars is 1.5AU from the Sun.

Some studies suggest on average, any planet that lies within 0.38 - 2 AU is likely to be habitable.

Let's filter those planets out first!

Here, we are creating a new list of **suitable_planets** and naming it as **goldilock_planets,** then we are iterating over all the suitable planets and we are removing the planets that have **orbital_radius** less than 0.38 or more than 2.

```
goldilock_planets = list(suitable_planets)

temp_goldilock_planets = list(suitable_planets)
for planet_data in temp_goldilock_planets:
  if planet_data[8] < 0.38 or planet_data[8] > 2:
    goldilock_planets.remove(planet_data)

print(len(suitable_planets))
print(len(goldilock_planets))
```

```
696
25
```

The list of suitable planets gives us **696** and out of those, only **25** are in Goldilock Zone! That's how rare it is! We are really lucky to have Earth!

By the way, can you tell me why the number of suitable planets got reduced from 1452 to 696?

ESR:
Because we removed the planets for which we did not have **orbital_radius**.

Awesome! Now, we also know the time it takes to complete one orbit (one complete rotation around the sun).

We, as humans, are accustomed to the speed at which our planet completes one revolution around our Sun, therefore we can only survive on the planets that have speed close to ours.

Earth travels at the speed of 30km/s. That's whooping but it's a fact! We cannot survive if the Earth increases/reduces its speed a lot. To calculate an exoplanet's speed, we do distance/time. We know the time it takes and we also know the radius of the orbit. Using the formula to find the circumference of a circle, we can find out the distance and the speed of the planet! Circumference of a circle = 2πr π = 3.14 r = radius of the orbit Let's find the planets using the above formula for distance.	
Teacher Stops Screen Share	
So now it's your turn. Please share your screen with me.	
Teacher Starts Slideshow **Slide # to #** <**Note**: Only Applicable for Classes with VA> Refer to speaker notes and follow the instructions on each slide.	
We have one more class challenge for you. Can you solve it? Let's try. I will guide you through it.	
Teacher Ends Slideshow	
STUDENT-LED ACTIVITY - 20 mins	
• **Ask the student to press the ESC key to come back to the panel.** • **Guide the student to start Screen Share.** • **The teacher gets into Full Screen.**	

Student Initiates Screen Share	
ACTIVITY • **Student finds the speed of all the planets** • **Student filters out the planets**	
Teacher Action	**Student Action**
Given what we have just learned, let's calculate the speed of all the planets that exist in **suitable_planets** list (696). Our Earth revolves around the sun at 30km/s. Similarly, our solar system revolves around the center of the Milky Way galaxy at the speed of 200km/s. You can only imagine how fast we are moving! Given this data, we can assume that if a planet revolves at the speed of 200km/s, we can survive that. We are already surviving at such high speeds! This means the planet that's in the Goldilock zone would take anywhere from 30 to 50 days to complete its 1 year (1 revolution around its sun). It would be 6-7 times faster than us. Also, make sure that we have the **orbital_period** in days. We need to convert it into seconds because we want to calculate the speed of the planet in **km/s** which is kilometers per second, instead of kilometers per day. **1 Day = 24 hrs = 24x60x60 = 86400 Seconds** We also need to convert our orbital radius from AU to Kilometers. **1 AU = 1.496 x 10 ^{8} km = 1.496e+8 km** Here, e stands for the exponential power that the unit has.	

We'll also filter out the planets that have speed more than 200km/s.

***Note:** Guide the student to open Student Activity 1. It is the same as the previous class code.*

Here, we are first creating a list of **planet_speeds** where we will keep all the speeds of the planets. We are then iterating over all the planets and finding their distance and time (and also converting distance from **AU to KM** and time from **Days to Seconds**).

We are finding out the speed of the planet with the formula and then adding this speed to the list.

```
planet_speeds = []
for planet_data in suitable_planets:
  distance = 2 * 3.14 * (planet_data[8] * 1.496e+8)
  time = planet_data[9] * 86400
  speed = distance / time
  planet_speeds.append(speed)
```

We are then repeating the same process we did earlier, creating a list **speed_supporting_planets** and then we are creating a temporary version of it to iterate.

We are then checking if the speed of the planet (**stored in the planet_speeds and we are finding it with the index of the planet data**) is greater than 200 km/hr or not. If it is more than 200km/he, we are removing the planet from the list. Finally, we are printing the length (number) of the planets whose speed can support us!

```
speed_supporting_planets = list(suitable_planets)

temp_speed_supporting_planets = list(suitable_planets)
for index, planet_data in enumerate(temp_speed_supporting_planets):
  if planet_speeds[index] > 200:
    speed_supporting_planets.remove(planet_data)

print(len(speed_supporting_planets))
```

```
676
```

We find out that 676 planets can support us in terms of speed.

We are indeed very lucky to have Earth as our home planet! Or maybe we evolved based on the conditions we have here and other planets might have some alien species too! You never know!

What's your take on Aliens?

ESR:
Varied

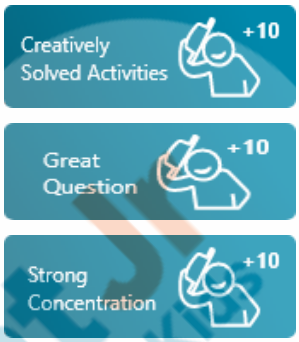
So, in this class, we learned about how we can calculate the speed of a planet, we also learned about the Goldilock zone and we filtered out even more planets to conclude that:

- **There are only 25 planets that have the right planet_type, gravity, and lie in the habitable zone of their solar system.**
- **There are 676 planets at the right speed to support us!**

How was your experience?

ESR:
Varied

Teacher Guides Student to Stop Screen Share	
WRAP-UP SESSION - 05 mins	
Teacher Starts Slideshow  **Slide # to #** <**Note**: Only Applicable for Classes with VA>	
Activity details **Following are the WRAP-UP session deliverables:** • Appreciate the student. • Revise the current class activities. • Discuss the quizzes.	
WRAP-UP QUIZ Click on In-Class Quiz	
Continue WRAP-UP Session  **Slide # to #** <**Note**: Only Applicable for Classes with VA>	
Activity Details **Following are the session deliverables:** • Explain the facts and trivia • Next class challenge • Project for the day • Additional Activity (Optional)	
FEEDBACK • **Appreciate and compliment the student for trying to learn a difficult concept.** • **Get to know how they are feeling after the session.** • **Review and check their understanding.**	
Teacher Action	**Student Action**

You get “hats-off” for your excellent work! Amazing. While working on this project, we also made sure that we are on top of all the concepts we have acquired so far. Next class, we will try to merge these lists and create a data collection. We will also try to explore a little about the suns of these planets!	*Make sure you have given at least 2 hats-off during the class for:* 
PROJECT OVERVIEW DISCUSSION Refer to the document below in Activity Links Sections	
Teacher Clicks 	

ACTIVITY LINKS		
Activity Name	**Description**	**Links**
Teacher Activity 1	Boilerplate Code	https://colab.research.google.com/drive/1EuBuJ8TK49Rg_wZuAX8iZ4zNgn30PX0p?usp=sharing
Teacher Activity 2	Reference Code	https://colab.research.google.com/drive/1C2IvEB4pKZm10Udbz7EIfm6hKjTkFiUb?usp=sharing
Teacher Reference 1	Project	https://s3-whjr-curriculum-uploads.whjr.online/2a2a97aa-a134-4aac-9e7b-004f76d0bace.pdf
Teacher Reference 2	Project Solution	https://colab.research.google.com/drive/1sENvt3EyvOSYYuDnVQeUDCC1ZyTh8T0Q?usp=sharing

Teacher Reference 3	Visual-Aid	WIll be added after VA creation
Teacher Reference 4	In-Class Quiz	https://s3-whjr-curriculum-uploads.whjr.online/6e03246b-e3b9-4d49-a75a-261969ae841e.pdf
Student Activity 1	Boilerplate Code	https://colab.research.google.com/drive/1CBGb5uXfc8ep5aehdjA75xBfWdeWG4x4?usp=sharing