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Trappist-1 Investigation

The habitability of planets is the suitability the planet has for habitation. When it comes to space, there are many planets that fall in the zone for habitability, however what is this "zone of habitability"? My project will show a system known to be the most "habitable system" due to it including 3 planets within the star's habitable zone. Through this project I want to learn about new types of functions and packages in python, and I decided to use the class function and pygame to simulate this system, including all planets. I also want to learn more about the star system and explain why or why not these planets can sustain life despite being in the habitable zone.

First question is why did I choose my star system? I chose the Trappist-1 system due to it being the most habitable system, and also due to it "not being too far away from us on an astrological scale (40 light years)." (Exoplanet Catalog). In the future, travel here could be beneficial to humans due to its short distance from us to find Earth 2.0. This trip however will only occur if this system is very likely to include habitable planets. Due to time dilation, this trip will feel instantaneous for the people in the near light speed jet, so travel here is not very unrealistic in the next thousand-years, though we are very far from it.

The Trappist system has a very close orbit to its star, Trappist-1. "One full revolution for the closest planet, Trappist-b is only 1.5 days." (TRAPPIST-1 StatisticsTable). On Earth this is 365 days and our closest planet in our solar system Mercury has an orbit of 88 days, a massive difference. This means the system is super close to the host star and the planets are tidally locked. Trappist-b, Trappist-c, and Trappist-d are super close and are inhabitable due to it being too hot for water to exist on the planet. Though, due to the planets being tidally locked, there is a chance that the dark side could system life or an area between the light and dark. “In March 2023, Webb discovered that the dark side of Trappist-b found little evidence of atmosphere.” (Exoplanet Discovery). “Trappist-h is too far to sustain life so that only leaves E, F, and G.” (Hubblesite).

The simulation I made using Python involved the rotation of these planets around its star. I am very curious about this as these planets are very close to their star so I want to see through simulation how fast they would be due to having a faster rotation because of their distance to their parent star Trappist-1. The code starts with the initialization of the variables in the class function “Planet”. I made all values for velocity and more in this init section of the class, which is where you initialize.

The next section is the draw section. The goal here is to draw lines for the planets to mark their orbit path. Code uses “pygame.draw.lines feature which draws a straight line. Afterwards, it uses pygame.draw.circle which makes a circular orbit path of the planet. When doing pygame.draw.circle it moves the planet and pygame.draw.lines draws a line behind it to show the orbit path the circle function took.” (Pygame Draw). There is another part that will include the speed of each planet in kilometers per second (km/s). If the planet is not the star, then it will state the speed the planet moves using the speed formula that is about to be defined.

Next function is attraction which uses the distance from a certain planet to every other planet in the system. This is because not only the star exerts a force of attraction but so does every other planet, and in this system planets are so close sometimes they get a distance apart from Earth to the Moon, making the night sky the planet. This is why I used other instead of just Trappist1. The formula is based off the x and y coordinates, by using the pythagorean theorem, I found the radius which is just $r = \sqrt{x^2 + y^2}$. If the other planet is the star I set an initialized value “distance_to_trappist1” to 0 and here we use that initialized value in init to make this value the distance (or r) as this value is just the distance from the star to the planet. Afterwards we need the force of attraction so I used the Force of Gravitation formula $Fg = \frac{GMm}{r^2}$. To find the angle we use $angle = arctan(\frac{y}{x})$. We need the angle as the force in the x and y direction will be different, $Fx = Fg * cos(angle)\ and\ Fy = Fg * sin(angle)$.

Update position will determine the amount each planet moves by the velocity. First I got the total force by summing each force in the x and y, getting total_fx and total_fy. Then using physics equations, I found the velocity by using $a = \frac{F}{m}$, then changing Force to total Fx and Fy. $ax = m,\ ay = \frac{Fy}{m}$, where m is mass. Then using the kinematics equation $v = vo + at$, I got velocity both x and y direction, which is the equations $vx = \frac{Fx}{m} * t,\ and\ vy = \frac{Fy}{m} * t$. Finally, I got the x and y positions using the equation $x = xo + .5 * at^2,\ y = yo + .5 * at^2$.

Final function is the window, which displays the pygame simulation from the math calculated. It defines the planets/star in the class. I also added an initial velocity as without it the planets will have no momentum and eject instead of orbiting. Then finally, added all the planets to a list then updated the position for each planet in the planet list in a for loop.

Some more information about the Trappist1 system is that despite all the info I list above being true, there is one downside to the planet which is that “trappist-1e is so close to its star that the fast orbit causes it to rip its own atmosphere… That's because Trappist-1e moves quickly around its star, and the motion drives powerful ionospheric currents that dissipate and create extreme heating, which the team calls voltage-driven Joule heating." (Lea). This means despite this planet being very much in the habitable zone, outside events are why life might not be able to survive. For the habitable zone to be so close to this system, it means that the star, Trappist-1 must be very small compared to our sun, with it being "12% the size of our sun." (Cooper).

From this investigation I have learned numerous new techniques in Python like classes which help organize the data and also pygame to simulate orbits, which can be applied to multiple other tasks. The code for my project has been broken and I spent around 5 hours debugging it to no success so for now the code does not work properly, however if I can fix it I will email the working code. Despite this setback however, I still learned a lot of new Python features as well as more about the Trappist-1 system and all of its planets.

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