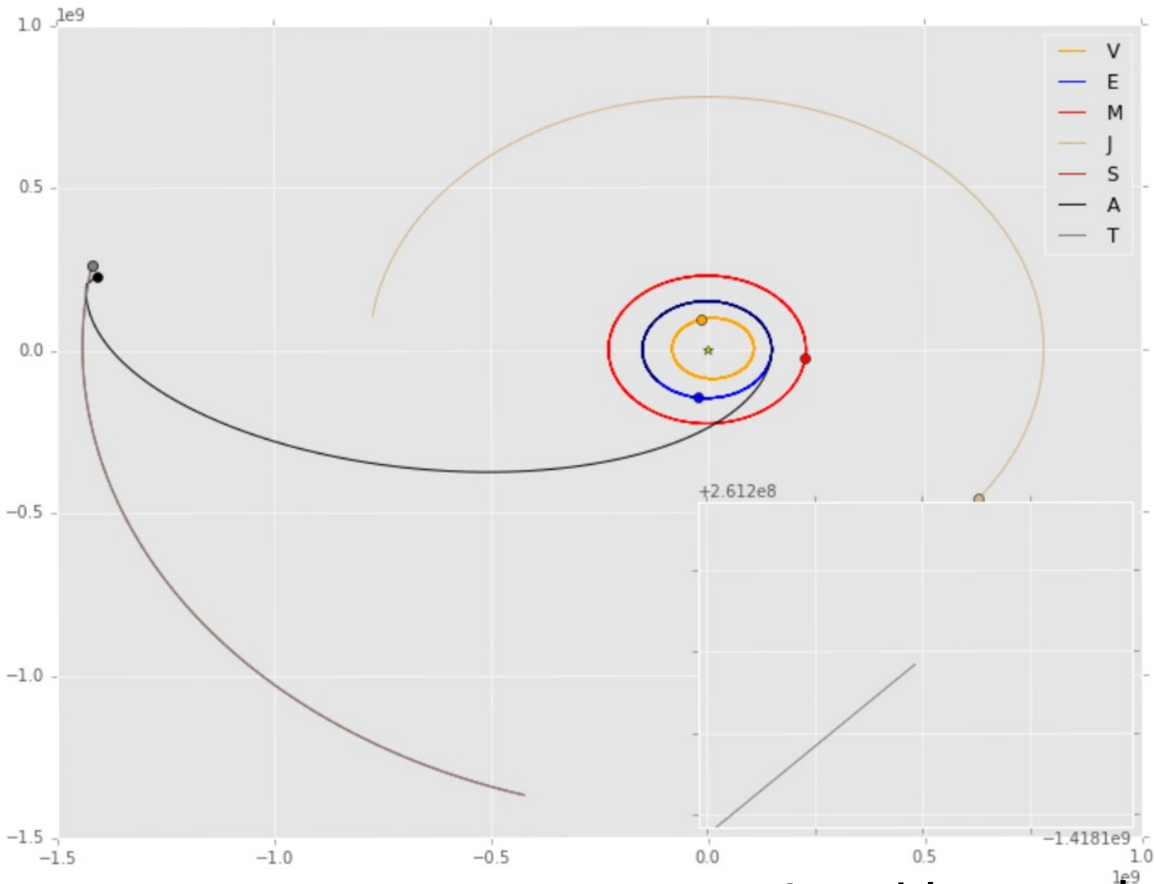

Figure 1: Example of gravitational interaction between Atlas and Saturn. Launch date = 230

Launch Date	Launch Velocity	Final Velocity
230	(-3.93e5, -2.56e6)	(3.57e5, 3.79e5)
231	(-4.46e5, -2.55e6)	(4.26e5, 2.40e5)
232	(-4.90e5, -2.54e6)	(7.74e4, 3.27e5)
233	(-5.25e5, -2.53e6)	(8.37e4, 3.38e5)
234	(-5.78e5, -2.52e6)	(9.15e4, 3.42e5)

Table 1: Minor changes in launch date cause significant changes to launch velocity. This affects final velocity, which determines whether ATLAS will fly-by or orbit Saturn.

Initially, ATLAS was introduced using classes and objects. The rocket had a dry mass and changing fuel mass that could aid in determining optimal energies to reach Titan.

```
class body:
    """defines a new class for bodies in our system
    Input:
    ------
    m
        mass of the body measured in kg
    r
        linear distance from the Sun (center of system) measured in
    th
        angular position measured in degrees
    v
        tangential velocity measured in km/s
    """

    def __init__(self,m,r,th,v):
        self.m = m
        self.r = r
        self.th = th
        self.v = v


Sun = body(1.989e30,0,0,0)
Venus = body(4.87e24,108.2e6,14.22,2.246991e2)
Earth = body(5.97e24,149.6e6,219.09,3.65200e2)
Mars = body(0.642e24,227.9e6,229.93,6.87e2)
Jupiter = body(1898e24,778.6e6,172.26,8.1660e2)
Saturn = body(568e24,1433.5e6,252.77,1.5145e3)
Titan = body(0.1345e24,1434.7e6,252.77,5.57)
```

The group soon found this method too difficult to implement and reverted back to simple NumPy arrays. The two main modules used were NumPy and Matplotlib, however an extension of Matplotlib named mpl_toolkits was used as well to create a zoomed in graph.

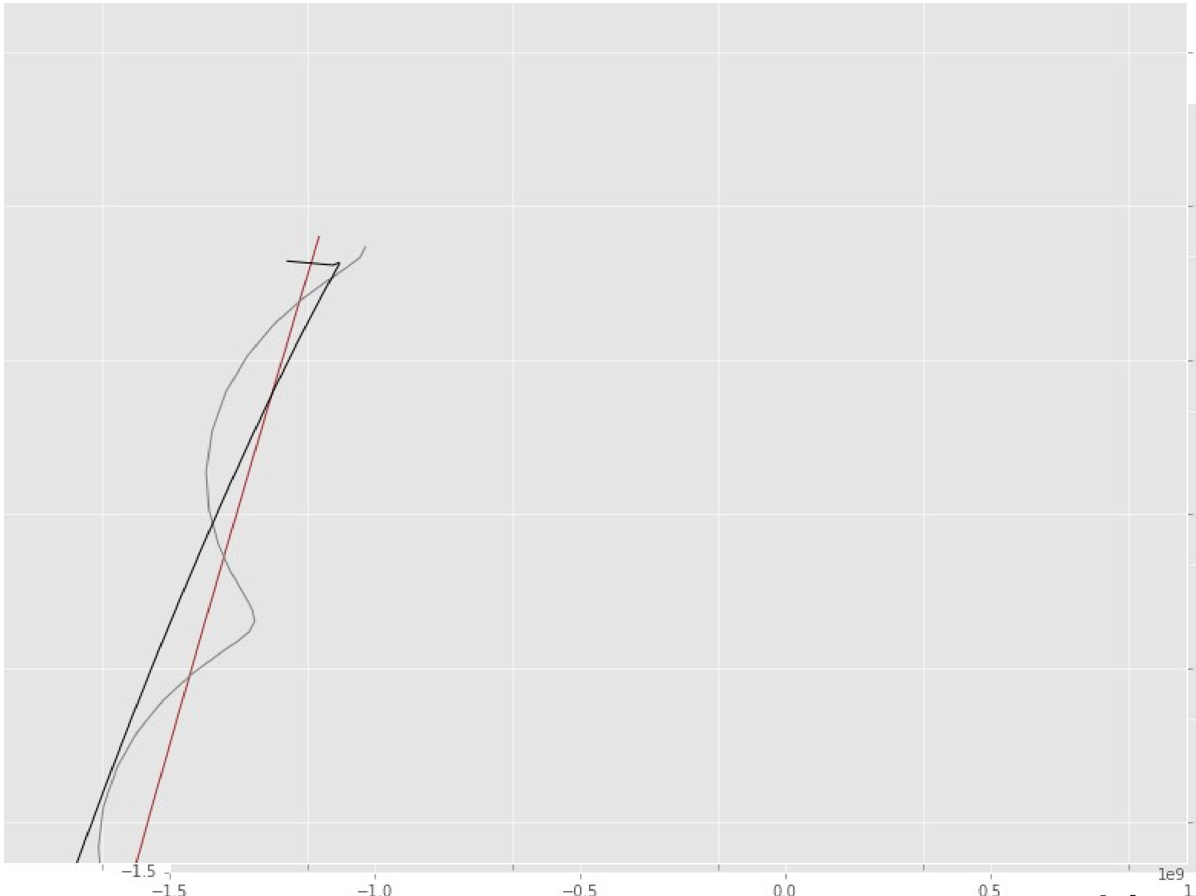

Figure 2: Example of ATLAS interaction with Titan-Saturn system.

This plot displays the interception of Atlas on the Saturn-Titan system. At this point 2 orbital maneuvers should deposit Atlas in a circular orbit around Titan. In this case, Titan was ejected. Observe the orbital motion of Titan around Saturn.