Note: You are free to use (e.g. copy verbatim) any text in black. All text in red indicates areas where you need to insert your own work.

Experiment #3: Asteroid interception

Introduction:
An asteroid is traveling toward earth with a nearly constant velocity. Earth Defense has launched all of its dedicated defense rockets to target the asteroid, but all have failed. All senior engineers from the previous launches are disgraced and have been sent to a small Pacific island that is the predicted location of the asteroid impact on earth. Responsibility for the survival of our civilization, and perhaps of all life, falls to you.

The only remaining defense rocket is a relic from the 1950's, the Red Dragon Planetary Defense Rocket (RDPDR), which was the first prototype rocket for Earth defense. It has no guidance system - once the engines are ignited it will operate until all fuel is exhausted. A single nuclear warhead fitted into the nose of the rocket is the only hope at deflecting the asteroid and will automatically detonate when the fuel is exhausted. Deflection of the asteroid occurs by detonating the nuclear warhead just off the surface so that the x-rays melt the surface of the asteroid, producing something like a small volcano, which acts like a brief rocket on the surface of the asteroid to change its trajectory.

Your job as a NASA Orbit Engineer, and last remaining engineer capable of such calculations, is to plan the trajectory of the RDPDR for interception of the asteroid. Earth Defense Headquarters has indicated that due to a hurricane bearing-down on Houston, the location from which the RDPDR will launch, there is a very narrow window for operations and the rocket must be launched in the next two hours.

NASA management offers you this last asset: you have at your disposal a short-range rocket called the Mark-IV booster that was a powerful rocket designed for lifting heavy payloads into low-earth orbit. The Mark-IV booster is itself incapable of reaching the asteroid, but you can use it to boost the speed of the RDPDR.

Experimental setup:
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Instructions: Report the information that you gathered today. Rather than just list the numbers, write a few sentences for each of the following: the general setup, the asteroid, the RDPDR, and the Mark IV rocket.

Note: In this analysis you will assume that Earth has no size, that is, you may treat it as a point from which you start by otherwise does not interfere with the trajectory of the rockets.
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Data and analysis:

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Instructions: Start with a statement about what you are trying to do. Then express that statement mathematically. Show how you derive an algebraic solution that you used to solve for the unknown quantities defining the problem.

Make a series of three plots that show the position, velocity and acceleration of each object. On each plot you should have two curves: one for the asteroid and the other for the RDPDR. Comment on the meaning of the intersection of the position graphs.

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Conclusion:

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Instructions: Reflect on your mission. Did you succeed? If not, what advice would you leave for the next species that must defend earth against a life-killing meteor (which is an asteroid that strikes the surface of a planet)? If you succeeded, how are you going to celebrate once you are the recognized savior of all of civilization and Earth?

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