Deflecting an Asteroid

Team 452

Problem A

**Abstract**

There are innumerable asteroids in this galaxy and in our solar system there are countless asteroids that are usually detached from the asteroid belt and float in space. A planet's gravity leaves a chance for asteroids to hit that planet. In this paper we have tried to find a mathematical solution for deflecting an asteroid that could hit the Earth by a spacecraft at the right time. For this we have used different types of mathematical equations and theory including Kepler theorem, different mathematical equations of deflection, orbital equation etc. Finally, we used these to calculate the impact time of the asteroid from the lower earth orbit and the impact time from an estimated distance to the earth, and from this we determined the time that the asteroid would deflect before the spacecraft hit the earth.

**1 Notations Used**

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Meaning** | **Numerical Value** |
| μ | Standard Gravitational Parameter | 3.986004418×1014 m3s-2 |
| rperigee | Perigee Radius of Earth |  |
| h | Angular Momentum |  |
| R | Earth Radius | 6378 km |
| Mn | Mean Anomaly |  |
| v | Speed of Asteroid |  |

**2 Problem Analysis**

In this problem we are given a situation where an asteroid can hit the Earth's surface with a velocity of 25 km/s. But we have placed a spacecraft in our lower earth orbit that can deflect the asteroid so that the asteroid doesn't hit the earth but passes by. In this case, it is said that the diameter of the asteroid is 100 meters and the mass of the spacecraft we are using to deflect it is 20000 kg.

**3 Introduction**

Asteroids of various sizes have hit our Earth at various times over thousands of years. Because of this, the world has had a catastrophic impact every time. It cannot be ruled out that this is unlikely to happen in the future. About 65 million years ago, a large asteroid hit the Earth and the dinosaurs disappeared from the Earth. The impact of this injury was many more years.

Whether an asteroid will hit Earth depends on several factors. One such is the size of the asteroid. Small asteroids often enter our Earth's atmosphere, most of which burn up in the atmosphere before reaching the surface. Again, some small pieces reach the surface of the earth which are collected and used in various research. However, the probability of a large impact is less than the probability of a small asteroid impact. According to scientists, such a possibility occurs once every 300,000 years. Scientists have found out that the last time around 65 million years ago, the Earth was hit by a large asteroid, which caused the temperature of the whole Earth to rise, and the Earth faced an apocalyptic situation.

To prevent asteroids from hitting the earth, first, all the small and big asteroids near the earth must be identified. Those asteroids are usually called NEO (near earth object). After that, scientists check the probability of those asteroids hitting the earth. For this, the orbit of that asteroid is observed very well day after day after month after year after year. After thorough observation they are categorized based on their various characteristics. Then, if an asteroid is found that has the potential to hit Earth, its orbit is deflected so that it misses Earth. In this case, the more time we get, the easier it will be for us to deflect the asteroid because we can figure out different ways to do it. Some of these methods, such as a large rocket or spacecraft, can be used to alter the asteroid's orbit using gravity. An asteroid can also be hit by a satellite causing the impact to change its trajectory. Again, in this case nuclear detonation can also be used. But trying to destroy an asteroid close to the Earth's atmosphere can backfire as it can have a nuclear bomb impact on the Earth.

**3.1 Asteroid**

There is an asteroid belt in our solar system between the planets Mars and Jupiter. In this belt there are countless small and large asteroids that orbit the Sun. Objects smaller than 600 miles in diameter that orbit the Sun are generally considered asteroids. Most asteroids orbit the Sun in an elliptical path and rotate in the same direction as the planets. Some asteroids from these asteroids may come close to the earth to rotate in its orbit. When the asteroid's orbit meets the Earth's orbit at a point. Due to this, the gravitational force of the earth is effective on the asteroid, so the probability of it hitting the earth increases many times. Asteroids near the earth are called NEO (near earth object) or NEA (near earth asteroid). There are also some asteroids that follow abnormal orbits. Asteroids come in different sizes. Again, their mass is also different. Usually, the mass of the asteroid is small in most cases. Asteroid rotation can also be different.

**3.2 Deflecting an Asteroid**

An asteroid can be deflected in various ways, one of which is to send a rocket carrying a nuclear bomb into space and hit the asteroid. This may change the trajectory of the asteroid, but this impact of the nuclear bomb will also have the possibility of falling on the earth if it is close to the earth. Another method could be to send a rocket or spacecraft with a certain speed or mass in the direction of the asteroid so that the rocket causes the asteroid's trajectory to change by changing its momentum. This is called a kinetic impactor.

**3.3 Impact of Asteroid on Earth**

Although most asteroids burn up in the atmosphere before reaching the Earth's surface, there are many asteroids that could impact Earth if they did reach the Earth's surface. And the larger the diameter of the asteroid, the greater the amount of impact on the earth. If a large asteroid were to hit the Earth, dust and smoke would cover the Earth's atmosphere, preventing sunlight from reaching the Earth, causing the extinction of many life forms in an instant. Even small asteroids can cause serious damage. It can kill many people. The Chelyabinsk Event, The Tunguska Event, The Chicxulub Event are some such incidents when an asteroid hit the Earth causing damage and loss of life. Moreover, the cataclysmic event that hit the coast of Mexico 65 million years ago brought a cataclysm to Earth that caused the extinction of the dinosaurs.

**3.4 Trajectories of an Object on Space**

By trajectory we mean the path along which an object or asteroid completes its rotation or passes through. Gravitational-attraction properties of concentrated masses of material are usually used to determine the different trajectories that asteroids take. Also, laws of newton are also considered in this matter. Trajectories are generally spherical in shape. Different types of trajectories are circular, elliptical, parabolic and hyperbolic.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Conic Section | Equation | Eccentricity(e) | Semi-major axis | Energy |
| Circle | x2+y2 = a2 | 0 | =radius | <0 |
| Ellipse | x2/a2+y2/b2 = 1 | 0<e= √(1-b2/a2)<1 | >0 | <0 |
| Parabola | y2=4ax, x2=4ay | 1 | infinity | 0 |
| Hyperbola | x2/a2 - y2/b2 = 1  x2/b2 - y2/b2 = -1 | e= √(1+b2/a2)>1 | <0 | >0 |