Name	Team Number

AAE 251: Introduction to Aerospace Design

Assignment 3—Orbits and Launch to LEO

Due Tuesday February 5, 10:00 am on Blackboard

NO 24 hr extension

Instructions

This assignment has six problems—four for the lecture Intro to Orbits, and two for lecture, Launch to LEO. The questions are a mix of derivations and numerical problems. Start the HW early, or you will run out of time!

Carefully read the lectures notes as they will be helpful to answer the questions. If you have questions, always ask for help from the TA.

Write or type your answers into the appropriate boxes. **Make sure you submit a single PDF on Blackboard.** *For the Matlab Code, you can either use Matlab's publishing feature and attach that to your homework or simply copy paste the code in Word and then make a PDF.*

There is no 24hr extension on this homework. Any submission after February 5, 10:00 am will not be accepted.

Problem Number	Points Possible	Points Earned
Problem 1	13	
Problem 2	4	
Problem 3	13	
Problem 4	15	
Problem 5	30	
Problem 6	5	
Total	80	

Introduction to Orbits

Question 1

In class, we saw that the equation of a conic section is given by:

$$r = \frac{p}{1 + e \cos(\theta^*)} \tag{1}$$

where $p = a(1 - e^2)$ is a geometrical constant of the conic called the "parameter" or "semi-latus rectum", e is the eccentricity, and θ^* is the true anomaly.

Your team launches a satellite into an orbit with a perigee radius of 7,000 km and an apogee radius of 10,000 km measured from the center of the Earth. You wish to calculate the altitude above the Earth's surface your satellite will attain when it has reached a point 90° past the perigee. To do so, follow these steps:

a) Draw a labeled sketch of the problem showing the orbit, perigee and apogee radius, and the position of the satellite at which we want to calculate the altitude.
b) Develop an expression for eccentricity in terms of perigee and apogee radius and calculate the value of eccentricity.
c) Calculate the semimajor axis for the orbit.
d) Use the polar equation of a conic section, Eq. (1), to calculate the desired altitude. Note that you need to report the altitude above the Earth's surface.

Answer 1:

Answer 1:

Question 2

Consider the satellite and the orbit you launched the satellite into in Question 1. What is the velocity magnitude of this satellite when the true anomaly is 90°? How long before the spacecraft returns to this point in the orbit?

Answer 2:

Answer 2:

Question 3

At two points on a geocentric orbit, the altitude and true anomaly are:

Point 1: $R_1 = 1545\ km$ and $\theta_1{}^* = 126^O$

Point 2: $R_2 = 852\ km$ and $\theta_2{}^* = 58^O$

Find:

a. the eccentricity of the orbit defined by these two points
Hint: equate the absolute value of the specific angular momentum, $h = \sqrt{\mu p}$ at these two points
b. the altitude of perigee
c. the semimajor axis
d. the orbital period

Answer 3:

Answer 3:

Question 4

The date is 02 September 1986 and you are an aspiring astrodynamics expert working at JPL. Today, Halley's comet is passing through perihelion. Using your state-of-the-art algorithm, you found that its orbit has eccentricity $e = 0.9671429$, and semi-major axis $a = 17.834144\ AU$.

A colleague runs in the room telling you that they have finally managed to figure out all the decimals of the Sun's gravitational parameter and it is equal to:

$$\mu_{Sun} = 1.327124400189 \times 10^{20}\ m^3/s^2$$

Then, they ask you to calculate the perihelion and aphelion distances, the current true anomaly, the specific total energy, the specific angular momentum, the period, and the current velocity magnitude of Halley's comet. (Use AU for distance units)

After completing your calculations, plot Halley's orbit in MATLAB. You need to use the conic equation as a function of the true anomaly, $0° \leq \theta^* \leq 360°$. Place the Sun at the center of your plot and add the Earth's orbit as well ($e_E = 0.0167, a_E = 1AU$). Is there a chance that the comet passes close to Earth? Do NOT forget to attach your MATLAB code at the end.

Answer 4:

Answer 4:

Launch to LEO

Question 5:

a. Fill out the Table with launch site information. Include the latitude, longitude, and location information of some important launch sites in the world.

b. At each launch site, compute the velocity due to Earth's rotation and include the value in the Table. Assume that the Earth's axis of rotation is perpendicular to the equatorial plane.

c. Assume that a multinational scientific organization wants to launch a spacecraft to LEO and is exploring various theoretical scenarios.

    i. Launch from Cape Canaveral to achieve a 90° inclination and $200\,km$ altitude circular orbit.

    ii. Launch from Kourou due East to achieve a 300 km altitude circular orbit.

    iii. Launch from Svalbard Rocket Range to achieve 90° inclination and 400 km altitude circular orbit.

Draw the launch velocity triangles and evaluate the "launch ΔV" for each of these scenarios and make your suggestion. Why did you pick that option?

Launch Site	Location	Latitude, deg	Longitude, deg	$v_{Earth\_rotation}$, m/s
Cape Canaveral				
Sriharikota				
Kourou				
Svalbard Rocket Range				
Baikonur Cosmodrome				

Answer 5:

Answer 5:

Question 6:

A spacecraft is to be launched from Cape Canaveral to the International Space Station (ISS). The ISS orbits at 51.6° inclination. Find the two possible launch azimuths for the launch vehicle. Which launch azimuth is more preferred and why?

Answer 6: