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Orbital Mechanics and Mission Design: Proceedings of an Aas/Nasa International Symposium, Held April , , at Nasa Goddard Space Flight Center.

You can help by adding to it. August Until the rise of space travel in the twentieth century, there was little distinction between orbital and celestial mechanics. Furthermore, the history of the fields are almost entirely shared. Johannes Kepler was the first to successfully model planetary orbits to a high degree of accuracy, publishing his laws in This was used by Edmund Halley to establish the orbits of various comets , including that which bears his name. The theory of orbit determination has subsequently been developed to the point where today it is applied in GPS receivers as well as the tracking and cataloguing of newly observed minor planets. List of orbits Rules of thumb[edit] The following rules of thumb are useful for situations approximated by classical mechanics under the standard assumptions of astrodynamics outlined below the rules. The specific example discussed is of a satellite orbiting a planet, but the rules of thumb could also apply to other situations, such as orbits of small bodies around a star such as the Sun. Orbits are elliptical , with the heavier body at one focus of the ellipse. Special case of this is a circular orbit a circle is a special case of ellipse with the planet at the center. A line drawn from the planet to the satellite sweeps out equal areas in equal times no matter which portion of the orbit is measured. A satellite in a low orbit or low part of an elliptical orbit moves more quickly with respect to the surface of the planet than a satellite in a higher orbit or a high part of an elliptical orbit , due to the stronger gravitational attraction closer to the planet. Thus one cannot move from one circular orbit to another with only one brief application of thrust. The consequences of the rules of orbital mechanics are sometimes counter-intuitive. For example, if two spacecraft are in the same circular orbit and wish to dock, unless they are very close, the trailing craft cannot simply fire its engines to go faster. This will change the shape of its orbit, causing it to gain altitude and actually slow down relative to the leading craft, missing the target. The space rendezvous before docking normally takes multiple precisely calculated engine firings in multiple orbital periods requiring hours or even days to complete. To the degree that the standard assumptions of astrodynamics do not hold, actual trajectories will vary from those calculated. For example, simple atmospheric drag is another complicating factor for objects in low Earth orbit. These rules of thumb are decidedly inaccurate when describing two or more bodies of similar mass, such as a binary star system see n-body problem. Celestial mechanics uses more general rules applicable to a wider variety of situations. In the close proximity of large objects like stars the differences between classical mechanics and general relativity also become important. Every orbit and trajectory outside atmospheres is in principle reversible, i. The velocities are reversed and the accelerations are the same, including those due to rocket bursts. Thus if a rocket burst is in the direction of the velocity, in the reversed case it is opposite to the velocity. Of course in the case of rocket bursts there is no full reversal of events, both ways the same delta-v is used and the same mass ratio applies. Standard assumptions in astrodynamics include non-interference from outside bodies, negligible mass for one of the bodies, and negligible other forces such as from the solar wind, atmospheric drag, etc. More accurate calculations can be made without these simplifying assumptions, but they are more complicated. The increased accuracy often does not make enough of a difference in the calculation to be worthwhile. The three laws are: The orbit of every planet is an ellipse with the sun at one of the foci. A line joining a planet and the sun sweeps out equal areas during equal intervals of time.

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Emergent provides technical services in the fields of orbital mechanics, astrodynamics, and trajectory design and optimization for a wide range of applications, from spacecraft mission design to space situational awareness.

Time of Periapsis Passage, T Longitude of Ascending Node, An orbiting satellite follows an oval shaped path known as an ellipse with the body being orbited, called the primary, located at one of two points called foci. An ellipse is defined to be a curve with the following property: The longest and shortest lines that can be drawn through the center of an ellipse are called the major axis and minor axis, respectively. Eccentricity is the distance between the foci divided by the length of the major axis and is a number between zero and one. An eccentricity of zero indicates a circle. An inclination of 90 degrees indicates a polar orbit. An inclination of degrees indicates a retrograde equatorial orbit. A retrograde orbit is one in which a satellite moves in a direction opposite to the rotation of its primary. Periapsis is the point in an orbit closest to the primary. The opposite of periapsis, the farthest point in an orbit, is called apoapsis. Periapsis and apoapsis are usually modified to apply to the body being orbited, such as perihelion and aphelion for the Sun, perigee and apogee for Earth, perijove and apojove for Jupiter, perilune and apolune for the Moon, etc. The argument of periapsis is the angular distance between the ascending node and the point of periapsis see Figure 4. The time of periapsis passage is the time in which a satellite moves through its point of periapsis. If the satellite crosses the plane going from south to north, the node is the ascending node; if moving from north to south, it is the descending node. Celestial longitude is analogous to longitude on Earth and is measured in degrees counter-clockwise from zero with zero longitude being in the direction of the vernal equinox. In general, three observations of an object in orbit are required to calculate the six orbital elements. Two other quantities often used to describe orbits are period and true anomaly. Period, P, is the length of time required for a satellite to complete one orbit. True anomaly, , is the angular distance of a point in an orbit past the point of periapsis, measured in degrees. The most energy efficient orbit, that is one that requires the least amount of propellant, is a direct low inclination orbit. Launching a spacecraft in a direction other than east, or from a site far from the equator, results in an orbit of higher inclination. Although high inclination orbits are less energy efficient, they do have advantages over equatorial orbits for certain applications. Below we describe several types of orbits and the advantages of each: Geosynchronous orbits GEO are circular orbits around the Earth having a period of 24 hours. A geosynchronous orbit with an inclination of zero degrees is called a geostationary orbit. For this reason, they are ideal for some types of communication and meteorological satellites. A spacecraft in an inclined geosynchronous orbit will appear to follow a regular figure-8 pattern in the sky once every orbit. To attain geosynchronous orbit, a spacecraft is first launched into an elliptical orbit with an apogee of 35, km 22, miles called a geosynchronous transfer orbit GTO. Polar orbits PO are orbits with an inclination of 90 degrees. An orbiting satellite is subjected to a great many gravitational influences. First, planets are not perfectly spherical and they have slightly uneven mass distribution. Also, the sun, moon, and planets contribute a gravitational influence on an orbiting satellite. The resulting orbit is called a walking orbit, or precessing orbit. In such an orbit, a satellite crosses periapsis at about the same local time every orbit. In order to maintain an exact synchronous timing, it may be necessary to conduct occasional propulsive maneuvers to adjust the orbit. Molniya orbits are highly eccentric Earth orbits with periods of approximately 12 hours 2 revolutions per day. The orbital inclination is chosen so the rate of change of perigee is zero, thus both apogee and perigee can be maintained over fixed latitudes. This condition occurs at inclinations of For these orbits the argument of perigee is typically placed in the southern hemisphere, so the satellite remains above the northern hemisphere near apogee for approximately 11 hours per orbit. This orientation can provide good ground coverage at high northern latitudes. Hohmann transfer orbits are interplanetary trajectories whose advantage is that they consume the least possible amount of propellant. It should be noted that the spacecraft continues to move in the same direction as Earth, only more slowly. This task is comparable to a quarterback "leading" his receiver so that the football and receiver arrive at the same point at the same time. The interval of time in which a spacecraft must be launched in order to complete its mission is called a launch window. The first law states that if no forces are acting, a body at rest will remain at rest, and a body in motion will remain in motion in a straight line. Thus, if no forces are acting, the velocity both magnitude and direction will remain constant. The second law tells us that if a force is applied there will be a change in velocity, i. This law may be summarized by the equation where F is the force, m is the mass of the particle, and a is the acceleration. The third law states that if body 1 exerts a force on body 2, then body 2 will exert a force of equal strength, but opposite in direction, on body 1. This law is commonly stated, "for every action there is an equal and opposite reaction". In his law of universal gravitation, Newton states that two particles having masses m1 and m2 and separated by a distance r are attracted to each other with equal and opposite forces directed along the line joining the particles. The common magnitude F of the two forces is where G is an universal constant, called the constant of gravitation, and has the value 6. Many of the upcoming computations will be somewhat simplified if we express the product GM as a constant, which for Earth has the value 3. The product GM is often represented by the Greek letter. For additional useful constants please see the appendix Basic Constants. For a refresher on SI versus U. Uniform Circular Motion In the simple case of free fall, a particle accelerates toward the center of the Earth while moving in a straight line. The velocity of the particle changes in magnitude, but not in direction. In the case of uniform circular motion a particle moves in a circle with constant speed. The velocity of the particle changes continuously in direction, but not in magnitude. This acceleration, called centripetal acceleration is directed inward toward the center of the circle and is given by where v is the speed of the particle and r is the radius of the circle. Thus, a particle undergoing uniform circular motion is under the influence of a force, called centripetal force, whose magnitude is given by The direction of F at any instant must be in the direction of a at the same instant, that is radially inward. A satellite in orbit is acted on only by the forces of gravity. The inward acceleration which causes the satellite to move in a circular orbit is the gravitational acceleration caused by the body around which the satellite orbits. Therefore, by setting these equations equal to one another we find that, for a circular orbit, Click here for example problem 4. Using the data compiled by his mentor Tycho Brahe , Kepler found the following regularities after years of laborious calculations: As Kepler pointed out, all planets move in elliptical orbits, however, we can learn much about planetary motion by considering the special case of circular orbits. These considerations apply equally well to the motion of a satellite about a planet. The large body of mass M moves in an orbit of constant radius R and the small body of mass m in an orbit of constant radius r, both having the same angular velocity. For this to happen, the gravitational force acting on each body must provide the necessary centripetal acceleration. Since these gravitational forces are a simple action-reaction pair, the centripetal forces must be equal but opposite in direction. That is, m 2r must equal M 2R. The specific requirement, then, is that the gravitational force acting on either body must equal the centripetal force needed to keep it moving in its circular orbit, that is If one body has a much greater mass than the other, as is the case of the sun and a planet or the Earth and a satellite, its distance from the center of mass is much smaller than that of the other body. If we assume that m is negligible compared to M, then R is negligible compared to r. This is a basic equation of planetary and satellite motion. It also holds for elliptical orbits if we define r to be the semi-major axis a of the orbit. Click here for example problem 4. In this case the size of the secondary cannot be ignored. The distance R is no longer negligible compared to r and, therefore, must be carried through the derivation. The semi-major axis used in astronomy is always the primary-to-secondary distance, or the geocentric semi-major axis. In such orbits both and r are constant so that equal areas are swept out in equal times by the line joining a planet and the sun. For elliptical orbits, however, both and r will vary with time. The area swept out by the radius vector in a short time interval t is shown shaded. This expression becomes more exact as t approaches zero, i. The rate at which area is being swept out instantaneously is therefore For any given body moving under the influence of a central force, the value r2 is constant. Since the velocity is always tangent to the path, it can be seen that if is the angle between r and v, then where vsin is the transverse component of v. Conservation of energy states that the sum of the kinetic energy and the potential energy of a particle remains constant. Applying conservation of energy we have From equations 4. During free flight the space vehicle is assumed to be subjected only to the gravitational pull of the Earth. If the vehicle moves far from the Earth, its trajectory may be affected by the gravitational influence of the sun, moon, or another planet. If we let point P2 represent the perigee, then equation 4. The smaller of the two answers corresponds to Rp, the periapsis radius. The other root corresponds to the apoapsis radius, Ra. Please note that in practice spacecraft launches are usually terminated at either perigee or apogee, i. This condition results in the minimum use of propellant. This angle is given by Click here for example problem 4. This angle is called the flight-path angle, and is positive when the velocity vector is directed away from the primary as shown in Figure 4. When flight-path angle is used, equations 4. Orbit Tilt, Rotation and Orientation Above we determined the size and shape of the orbit, but to determine the orientation of the orbit in space, we must know the latitude and longitude and the heading of the space vehicle at burnout.

Chapter 3 : Orbital mechanics - Wikipedia

The present conference discusses topics in LEO mechanics, the earth-sun-moon orbital regime, space navigation, and lunar and planetary missions.

As I performed my research it became apparent that most information on the subject tended toward one of two extremes: I could find little information suitable for the space enthusiast who wanted to progress beyond the beginner level but who lacked the advanced math and science skills needed to understand the more complex texts. After spending months digging through books and Internet sites I finally found the information needed to complete my project. Not wanting others to go through the same frustrating search, I decided to organize all the information into a single resource. Thus, in this Web page was created. Most of the information from my original research can be found in the Basics of Space Flight section. Through the years additional information and sections have been added. It is my hope this site continues to grow and improve. Please enjoy your visit and learn a little about the fascinating science of space flight. You can visit any page by clicking on the section titles in the Table of Contents to the right or by clicking on any of the highlighted links. If you entered this site through the main index page will see a navigation bar across the bottom of this window. This bar includes links to all the major sections of this Web site. Alternatively, you can use the drop-down menu at the bottom of each page. Clicking "Home", either on the navigation bar or at the bottom of a page, will return you to this home page. If the navigation bar is not visible, try clicking Navigation Bar now to activate. Basics of Space Flight The Basics of Space Flight section is a tutorial designed to teach the basic science behind rocketry and space flight. Part I, Rocket Propellants , compares the properties of the various fuels and oxidizers used in rocketry. Part II, Rocket Propulsion , explains how rockets work and examines how engines convert chemical energy into thrust. Part III, Orbital Mechanics , discusses how space vehicles move under the influence of forces such as gravity, thrust, and drag. Part IV, Interplanetary Flight , studies the trajectories used to travel between planets. This section is not for those with an aversion to mathematics as we focus largely on problem solving. Although some derivations use calculus, application of the derived formulae requires no more than an understanding of algebra and trigonometry. Each section includes example problems to demonstrate the use of the formulae. I have personally authored only a small part of the text contained in Basics of Space Flight. The information was mostly assembled piecemeal from a variety of sources. I hope you find the final product a useful and well-organized compilation. All sources have been credited in my Bibliography page. Space Hardware The Space Hardware section describes many space vehicles and launchers. Part I, Spacecraft Systems , defines the most common types of spacecraft and describes their primary subsystems. Space Missions The Space Missions section provides comprehensive lists of all major manned and robotic space flights. Part I, Manned Space Flights , includes all piloted manned missions by all nations. Part II, Planetary Spacecraft , includes most interplanetary space probes and landers. These lists include not only the successful missions but the many failed attempts as well. Satellites such as Sputnik and Explorer I, and observatories such as the Hubble Space Telescope, although historically and scientifically important, are not included because they do not fall into any of the three classifications described above. Also provided are a list of the number of orbital launches by site, complete through , and a map showing the location of each launch center. Discussion Forum The Discussion Forum , provided courtesy of The Space Race , is a good place to talk about space science and technology. You can ask questions and learn about rockets, space exploration, or any other related topic; or you can share your knowledge and help others. If you wish to engage in a discussion about any of the items found in this Web site, I recommend you visit the forum. Although I am happy to correspond via email , the forum will allow more people to contribute to the discussion. Site Logo This photograph is a view of the Gemini 7 spacecraft taken from the hatch window of Gemini 6 during rendezvous and station keeping maneuvers at an altitude of approximately miles on December 15, NASA Photo ID S This mission achieved the first rendezvous of two spacecraft. It was a critical milestone that without which a landing on the moon would have been impossible. This mission and the Gemini flights that followed taught Americans how to maneuver and work in space. Deleted Moon Landing Hoax section. Added "Gravitational Assist" to the

Interplanetary Flight section. Added the appendix Rocket Thermodynamics. Revised the Orbital Mechanics section. Added design information about nozzle shapes and combustion chambers to the Rocket Propulsion section. Reorganized and renumbered the Basics of Space Flight section. Added new material to the Rocket Propulsion and Orbital Mechanics sections. Made additions to the Rocket Propulsion section. Added Propellant Combustion Charts. Updated Atlas and Delta launch vehicles. Made extensive revisions and additions to the Orbital Mechanics section. Converted all example problems to the SI System of units. The entire Web site was given a major makeover. The home page was redesigned, several pages were consolidated, and site navigation was improved. Link to the discussion forum was added.

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Chapter 4 : Orbital Mechanics Specialization | Physics Forums

Orbital mechanics, also called flight mechanics, is the study of the motions of artificial satellites and space vehicles moving under the influence of forces such as gravity, atmospheric drag, thrust, etc. Orbital mechanics is a modern offshoot of celestial mechanics which is the study of the motions of natural celestial bodies such as the moon and planets.

Insights Author Aerospace systems engineering is a lot more than spacecraft mission design. You need to be a jack of all trades, master of at least one. That can be a tough road to follow, but it can be lead to a potentially lucrative and influential career. That is a job for a true specialist; systems engineer are generalists by the nature of their work and by their own nature. Specializing in orbital mechanics is a technical specialization. It is a very different road than systems engineering, and a more traditional road for the typical somewhat nerdish engineer. BTW, you did not mention guidance, navigation, and control. That is another field actually, set of fields somewhat similar to orbital mechanics. You will need to know orbital mechanics quite well if you aim for guidance or navigation. So the big question: Are you, by your nature, a generalist or a specialist? Your interests appear to be divided. You dive very deep into some very specific and very important technology, eventually becoming the world-renowned expert in that field. You are a very adroit technical manager, eventually becoming the lead system engineer on a very high profile project. Your next step, who knows? Which of these appeals to you more? Which be honest to yourself better suits your personality, skills, and interests? Which be real honest with yourself do you think you would eventually be happy and successful with even if those Mittyesque dreams do not come to pass? Most of the better aerospace schools now have a systems engineering track. Stanford is far, far from alone in this realm. It is not even the lead in this realm not even close, IMHO.

Chapter 5 : Orbit Mechanics Course | Engineering Courses | Purdue Online Learning

It is a core discipline within space mission design and control. Celestial mechanics treats more broadly the orbital dynamics of systems under the influence of gravity, including both spacecraft and natural astronomical bodies such as star systems, planets, moons and comets.

This is only a rough scale. This scale may be adjusted depending on the performance of the class. Any adjustments to the scale will only lower the cut-offs to achieve a specifed grade; cut-offs will not be raised beyond those listed here. Other course structures will have equivalent workload expectations as described in the syllabus. You are responsible for regularly checking with the messaging system through MySJSU or other communication system as indicated by the instructor to learn any updates. University Policies Dropping and Adding Students are responsible for understanding the policies and procedures about adddrop, grade forgiveness, etc. Adddrop deadlines can be found on the current academic year calendars document on the Academic Calendars webpage at http: The Late Drop Policy is available at http: Students should be aware of the current deadlines and penalties for dropping classes. Information about the latest changes and news is available at the Advising Hub at http: Such permission allows the recordings to be used for your private, study purposes only. The recordings are the intellectual property of the instructor; you have not been given any rights to reproduce or distribute the material. You may not publicly share or upload instructor generated material for this course such as exam questions, lecture notes, or homework solutions without instructor consent. Academic integrity Your commitment as a student to learning is evidenced by your enrollment at San Jose State University. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http: Instances of academic dishonesty will not be tolerated. For this class, all assignments are to be completed by the individual student unless otherwise specified. Campus Policy in Compliance with the American Disabilities Act If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive at http: In , the Disability Resource Center changed its name to be known as the Accessible Education Center, to incorporate a philosophy of accessible education for students with disabilities. Additional computer labs are available in engineering department. Computers are also available in the Martin Luther King Library. A wide variety of audio-visual equipment is available for student checkout from Media Services located in IRC These items include DV and HD digital camcorders; digital still cameras; video, slide and overhead projectors; DVD, CD, and audiotape players; sound systems, wireless microphones, projection screens and monitors. SJSU Peer Connections Peer Connections, a campus-wide resource for mentoring and tutoring, strives to inspire students to develop their potential as independent learners while they learn to successfully navigate through their university experience. You are encouraged to take advantage of their services which include course-content based tutoring, enhanced study and time management skills, more effective critical thinking strategies, decision making and problem-solving abilities, and campus resource referrals. In addition to offering small group, individual, and drop-in tutoring for a number of undergraduate courses, consultation with mentors is available on a drop-in or by appointment basis. Workshops are offered on a wide variety of topics including preparing for the Writing Skills Test WST , improving your learning and memory, alleviating procrastination, surviving your first semester at SJSU, and other related topics. Peer Connections is located in three locations: Visit Peer Connections website at http: In classes where active participation of students or guests may be on the recording, permission of those students or guests should be obtained as well. Page generated

Chapter 6 : Basics of Space Flight: Orbital Mechanics

This textbook covers fundamental and advanced topics in orbital mechanics and astrodynamics to expose the student to the basic dynamics of space flight.

Chapter 7 : NASAâ€™s Tool for Calculating Orbital Tracks Aids in Spacecraft Design | NASA

This module elaborates the fundamental concepts of spaceflight orbital mechanics and introduces trajectory design for planet centred and interplanetary missions. It starts with a short review of the two-body problem and introduces the design and characterisation of planet-centred orbits in presence.

Chapter 8 : Rocket and Space Technology

Get this from a library! Orbital mechanics and mission design: proceedings of an AAS/NASA international symposium, held April , , at NASA Goddard Space Flight Center, Greenbelt, Maryland.

Chapter 9 : SESA | Spacecraft Orbital Mechanics and Control | University of Southampton

AE Orbital Mechanics & Mission Design Fall Page 2 of 5 Course Goals 1. To provide a fundamental knowledge of orbital mechanics.