EAS 4510
Astrodynamics
Spring 2017

Exam 2
22 March 2017

What is Allowed During Examinations and Homework

You may use any books, your personal notes, or electronic aid, provided that you find the material on your own without having it provided to you by anyone else (either implicitly or explicitly). **You may not, under any circumstances, communicate with anyone about this assignment, and that includes me and the TAs!** Any violations of these rules will result in further action on my part in a manner consistent with the academic honesty policy of the University of Florida. The academic honesty policy can be found at the Student Conduct and Conflict Resolution website:
https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/

Guidelines for Solutions

Communication is an extremely important part of demonstrating that you understand the material. To this end, the following guidelines are in effect for all problems on the examination/homework:

1. Your handwriting must be neat. I will not try to decipher sloppy handwriting and will assume that something is incorrect if I am unable to read your handwriting.
2. **ONLY FOR IN-CLASS EXAMS:** Your exam must be HANDWRITTEN, no software, no scans, etc., your own handwriting ONLY. If anything else appears other than your own handwriting, the exam will be evaluated at 0 (zero).
3. You must be crystal clear with every step of your solution. in other words, any step in a derivation or statement you write must be unambiguous (i.e., there must be one and only one meaning). IF it is ambiguous as to what you mean in a step, then I will assume the step is incorrect.
4. Exams without a name on each page, and/or without a UFID and signature at the bottom of this page, will not be graded (i.e., they will receive a score of 0 (zero)).
5. ANY assignment (HW, exam, etc.) submitted without a completed signature, date, or UFID at the bottom of this page will not be graded (i.e., they will receive a score of 0 (zero)).

In short, please write your solutions in an orderly fashion so that somebody else can make sense of what you are doing and saying. Finally, credit will be given only if a relevant concept is applied properly, and no credit will be given for an incorrectly applied concept even if the final answer is correct.

University of Florida Honor Code

On your examination/homework you must state and sign the University of Florida honor pledge as follows:

On my honor, I have neither given nor received unauthorized aid in doing this examination/homework.

Signature: **Date:**

University of Florida ID:

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1. Consider the orbits on the attached page. If the *ECI* coordinate system is defined using $\{\hat{\boldsymbol{x}}, \hat{\boldsymbol{y}}, \hat{\boldsymbol{z}}\}$ and $\boldsymbol{e}$ is the eccentricity vector, circle the correct statements regarding the orbital elements of Spacecraft 1 and Spacecraft 2. **(30 Points)**

   - *Semi-Major Axis:*

     $a_1 > a_2$ $a_1 < a_2$ $a_1 = a_2$

   - *Eccentricity:*

     $e_1 > e_2$ $e_1 < e_2$ $e_1 = e_2$

   - *Inclination:*

     $i_1 > i_2$ $i_1 < i_2$ $i_1 = i_2$

   - *Right Ascension of the Ascending Node (RAAN):*

     $\Omega_1 > \Omega_2$ $\Omega_1 < \Omega_2$ $\Omega_1 = \Omega_2$

   - *Argument of Perigee:*

     $\omega_1 > \omega_2$ $\omega_1 < \omega_2$ $\omega_1 = \omega_2$

   - *True Anomaly:*

     $\theta_1 > \theta_2$ $\theta_1 < \theta_2$ $\theta_1 = \theta_2$

2. Determine the total Δv required for a Hohmann transfer from a circular orbit with radius $r_1 = 7,000$ km to a circular orbit of radius $r_2 = 42,000$ km. **(15 Points)**

3. Determine the total Δv required for a bi-elliptic transfer from a circular orbit with radius $r_1 = 7,000$ km to a circular orbit of radius $r_3 = 42,000$ km using an intermediate orbit with radius $r_2 = 55,000$ km. **(15 Points)**

4. A satellite's position is measured in the *ECI* coordinate system to be $\boldsymbol{r} = 10,000\hat{\boldsymbol{y}} + 5,000\hat{\boldsymbol{z}}$ in kilometers. If the Greenwich Mean Sidereal Time is given as $\theta_{GMST} = 248^\circ$ determine the satellite's longitude and latitude coordinates. **(15 Points)**

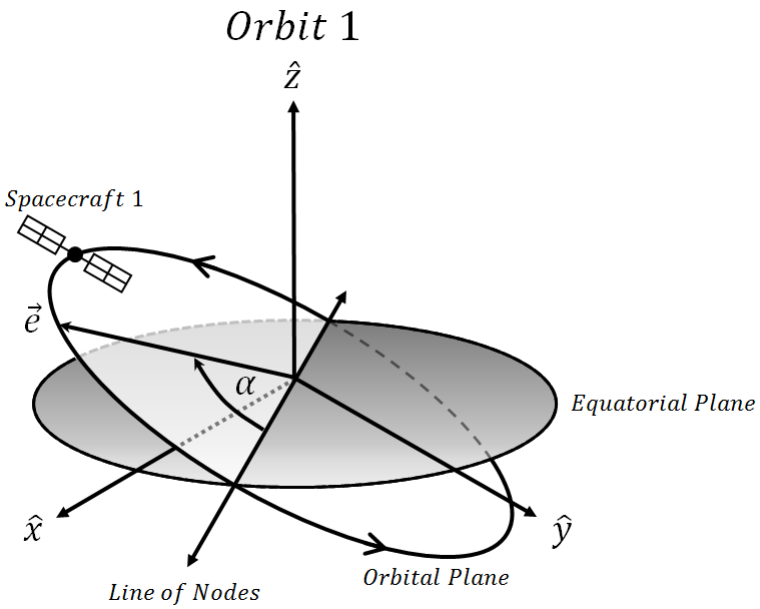
5. The conversion between a satellite's *ECI* coordinates and orbital elements is performed using a 3-2-1 Euler sequence. **(True/False) (5 Points)**

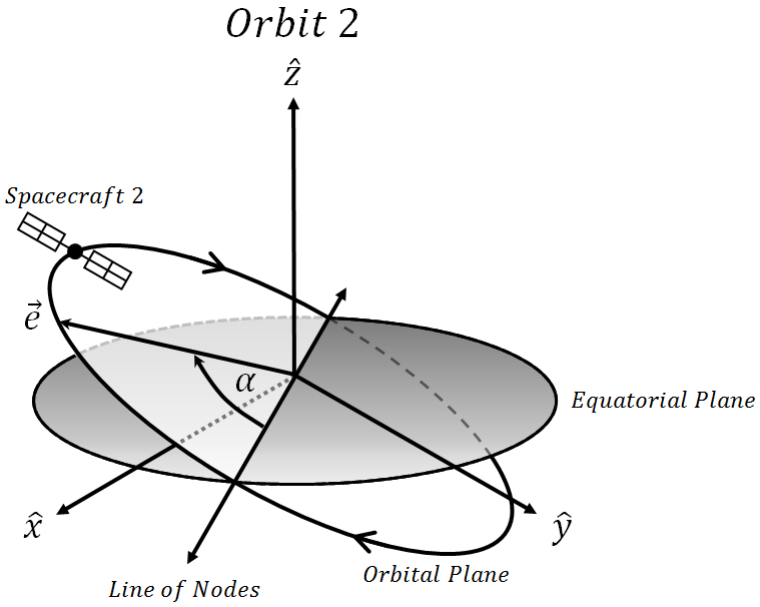
6. Hohmann transfers always require less Δv compared to bi-elliptic transfers because they require fewer burns. **(True/False) (5 Points)**

7. A satellite with an inclination of $i = 90^\circ$ is said to be in a polar orbit. **(True/False) (5 Points)**

8. Inclination angles are bounded between 0° and 180°. **(True/False) (5 Points)**

9. Circular, equatorial orbits do not have uniquely defined RAAN (Ω), argument of perigee (ω), or true anomaly (θ) values. **(True/False) (5 Points)**





Note:

- Angle $\alpha < 90°$ lies in the orbital plane, indicating the lesser angle between $\boldsymbol{e}$ and the line of nodes.
- $r_{a,1} = r_{p,2}$
- $r_{p,1} = 0.8 r_{a,1}$
- $r_{p,2} = 0.8 r_{a,2}$

Solutions

1.

Semi-Major Axis:

$a_1 < a_2$

Eccentricity:

$e_1 = e_2$

Inclination:

$i_1 < i_2$

Right Ascension of the Ascending Node (RAAN):

$\Omega_1 > \Omega_2$

Argument of Perigee:

$\omega_1 > \omega_2$

True Anomaly:

$\theta_1 > \theta_2$

2. $\Delta v = 3.77 \frac{\text{km}}{\text{sec}}$ or 0.4993

3. $\Delta v = 3.93 \frac{\text{km}}{\text{sec}}$ or 0.5209

4. latitude: 26.56° longitude = 202°

5. False

6. False

7. True

8. True

9. True