EAS 4510
Astrodynamics
Spring 2017

Exam 3
19 April 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 a spacecraft in a perfectly Keplerian orbit 7000 km from the center of Earth, whose current state is given by $\mathbf{x} = \left[51485\frac{\text{km}^2}{\text{s}} \quad 0.1 \quad \frac{\pi}{4} \quad \frac{\pi}{2} \quad \frac{2\pi}{3} \quad \frac{4\pi}{3}\right]^{\text{T}}$, where $\mathbf{x} = [h \quad e \quad i \quad \Omega \quad \omega \quad \theta]^{\text{T}}$. An impulse is applied in a direction parallel to the angular momentum vector, resulting in a perturbing acceleration of magnitude P. Determine the time derivatives of the orbital elements, using the Gauss Variational Equations, at the instant of the maneuver. **(30 Points)**

2. Spacecraft 1 and Spacecraft 2 are in equatorial circular orbits around the Earth with positive angular momentum. Spacecraft 1 has a longitude of 90° in the *ECI* coordinate system and is located 600 km above the Earth. Spacecraft 2 has coordinates $\mathbf{r} = [10 \quad 0 \quad 0]^{\text{T}}$ km in the *LVLH* coordinate system centered on Spacecraft 1. Determine the position and velocity vectors for both spacecraft in the *ECI* coordinate system. **(20 Points)**

3. An asteroid is on a trajectory that will bring it to within 550,000 km of Mars. Will the asteroid continue on its current trajectory or will the gravity of Mars alter the asteroid's orbit? Support your answer mathematically. **(15 Points)**

   Useful information:

   Mass of Mars: 641.9×10^{21} kg
   Mass of Sun: 1.989×10^{30} kg
   Distance from Sun to Mars: 227.9×10^{6} km

4. List two examples of non-gravitational perturbations. **(10 Points)**

5. Sun-synchronous satellite orbits are maintained primarily as a result of the J2 perturbation. **(True/False) (5 Points)**

6. For a planetary flyby, the magnitude v_∞ is the same while entering and exiting the planet's sphere of influence. **(True/False) (5 Points)**

7. The Clohessy-Wiltshire equations model relative motion with respect to a satellite in a *circular* orbit. **(True/False) (5 Points)**

8. In the *LVLH* coordinate system defined by basis vectors $\left\{\hat{R}, \hat{S}, \hat{W}\right\}$, the $\hat{S}$ basis vector always points along the direction of the satellite's velocity vector, regardless of the shape of the orbit. **(True/False) (5 Points)**

9. An Earth-based satellite on a parabolic orbit will escape Earth-orbit. The resulting orbit will place the satellite on the Earth's same trajectory around the sun. **(True/False) (5 Points)**

Solutions

1. All GVEs are equal to zero except for $\frac{\mathrm{d}i}{\mathrm{d}t} = 0.136P$ and $\frac{\mathrm{d}\theta}{\mathrm{d}t} = \frac{h}{r^2}$.

2. $\boldsymbol{r_1} = 6978\hat{\boldsymbol{y}}$ km $\quad$ $\boldsymbol{r_2} = 6988\hat{\boldsymbol{y}}$ km $\quad$ $\boldsymbol{v_1} = -7.5579\hat{\boldsymbol{x}}\ \frac{\mathrm{km}}{\mathrm{s}}$ $\quad$ $\boldsymbol{v_2} = -7.5525\hat{\boldsymbol{x}}\ \frac{\mathrm{km}}{\mathrm{s}}$

3. Mars SOI $= 577,135$ km so the asteroid will be placed on a new trajectory.

4. (a) Thrust

   (b) Atmospheric Drag

   (c) Solar Radiation Pressure

   (any perturbation not due to celestial gravity or oblateness effects)

5. True

6. True

7. True

8. False

9. True