



کراچی یونیورسٹی
University of Karachi
Department of Mathematics
MATH 717: Astrodynamics I

Time Allowed: 2 hours • Maximum Marks: 50 • Date: Monday, August 1, 2011 • Paper Format: A

Student's Name _____ (in CAPITAL LETTERS using a "marker")

Attempt all questions. Each part of Question 1 is of 7 marks and that of Questions 2-5 is of 4 marks. Note down the time spent on solving each part of question and time spent on revision by making the following "Time Chart" on the answerbook front page (2 marks). Time spent on revision must be at least 10% of the total time.

Question No.	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	Revision
Time (minutes)											

a) DO NOT TURN PAPER AROUND unless the invigilator says: *Start now*

b) This is a closed-book examination. Deposit all BOOKS, NOTES, MOBILE PHONES (switched off), DIGITAL DIARIES and LAPTOPS in the designated area. Remove everything from your desk, except markers, pens, pencils, stapler and calculator.

c) If you want to use a calculator, **it must bear a "sticker"** displaying your NAME and your SEAT NUMBER, large enough so that it is visible from a distance of 5 meters. **Absolutely, NO sharing of calculators.**

d) Use your own material. **Nothing can be borrowed from or given to** a friend.

e) The papers may be of different formats. Therefore, work on your own **without consulting anyone** (We have a record of your seating arrangement).

f) Write your "NAME" on all pages of **your question paper** (5 marks shall be deducted for failing to comply) [NOTHING ELSE SHOULD BE WRITTEN ON THE QUESTION PAPER] and "PAPER FORMAT" on the front page of **your answerbook** (the upper-right-hand corner) and the **Yellow Sheet** using a "marker". Start your work from **Page 2** of your answerbook. The only thing that could be written on the front page is the "Time Chart" (see above) and the "Honor Statement" (see below).

g) The following statement must be copied on the front page of your answerbook and signed (2 marks): *"My signatures, below, testify that I am the person, whose name and photograph appear on the Admit Card. Upon my honor, I declare that the following work is my own, completed without giving or receiving unacknowledged help, without copying, or the use of any unfair means."* Signatures _____

h) This paper contains TWO PAGES (this page and the back page). On invigilator's signal (*Start now*) turn the paper around, check if you have the back page printed, correctly. Last line of the second

page reads: <END>. Start working on the paper, immediately.

i) Put your pens down and your papers turned (so that this page is facing you) and the FRONT PAGE of your answerbook should be facing you as soon as you hear "**ALL PENS DOWN**". Failure to do as directed shall result in "deduction of 5 marks" from your score.

j) If you use extra copies, it is "**your responsibility**" to write YOUR NAME, COPY NUMBER and all OTHER INFORMATION on each copy used. All the extra copies must be stapled with the main copy, before turning in your paper (you may wish to bring in a stapler with you for this purpose).

k) If you have a question of "Fill in the blanks" in your paper you must write the complete sentence with the filled word underlined.

l) Nobody is allowed to leave the examination hall, **for whatsoever reason**, once the examination has started. Bring your own DRINKING WATER.

m) Students are not allowed to LEAVE THEIR SEATS or STAND UP during the examination. If you have a query, "raise your hand" and someone will help you.

n) All work, including rough work, must be on the official answerbook. No extra sheet may be used.

o) Students are **not** allowed to use RED anywhere. All work (except figures) must be in pen or ballpoint.

p) The result shall be displayed on my homepage on **Tuesday, August 16, 2011 at 1430h**. DO NOT contact the Course Supervisor. Students are not permitted to see the answerbooks.

q) Anyone found cheating in the examination should be facing disciplinary action, which may result in **EXPLUSION** or **SUSPENSION** for 2 or more years. **Absolutely, no conversation among students. DON'T TURN THE PAPER, YET. Wait for "signal" from the invigilator.**

Student's Name _____ (in CAPITAL LETTERS using a "marker")

- 1-a) Obtain the transformation matrix representing rotation about z axis through an angle q . Show that the set of transformation matrices, representing rotations about z axis, form an *abelian group* under the operation of matrix multiplication.
- 1-b) What are the different approaches taken for problem solving, in the classroom, in the laboratory, and in the industry? Describe, in detail, the steps involved for classroom-problem solving.
- 2-a) What is INS? Which inertial sensors are used in INS?
- 2-b) On page 13 of *Battin: An Introduction to the Mathematics and the Methods of Astrodynamics*, the author tries to show that constant in the equation:

$$\frac{\nabla \times \mathbf{v}_c}{\rho} = \text{constant}$$

vanishes by the following argument. "The demonstration concludes with an argument that the fluid is converging on the target point $\mathbf{r}_T$ so that the density in the vicinity of $\mathbf{r}_T$ is becoming infinite. *Hence, the constant is zero, implying that the curl is everywhere zero.*" There are 2 problems with this line of argument. Mathematically, elaborate them.

- 3-a) Compute the scale factors for the spherical-polar-coördinate mesh.
- 3-b) List 5 types of coördinate transformations discussed in class.
- 4-a) Draw the following table in your answer book and fill in the blanks:

<i>Spacetime Symmetry</i>	<i>Mathematical Representation</i>	<i>Conserved Quantity</i>
Space-translational symmetry (homogeneity)		
Rotational symmetry (isotropy)		
Time-translational symmetry (stationary)		

- 4-b) Consider a surface-to-surface missile thrown upward with a velocity, v_0 , at an angle, ' q ', with the horizontal. Consider motion under constant ' g '. Compute the total transfer time (time-of-flight), range, flight-direction angle and velocity as a function of time, ' t '.
- 5-a) What are active and passive transformations? Illustrate with an example.
- 5-b) What would be the ratio of escape velocity of a rocket from planet 'X' to that from earth if mass of planet 'X' is 20 times the mass of earth and its radius is three-fourth the radius of earth.

Web address of this document: http://www.ngds-ku.org/M725-6/Exams725-6/725-11_Paper.pdf
(to be uploaded 12 hours after the conclusion of examination)

Exam paper solution: Tuesday, September 13, 2011 at 1430h, i. e., 2: 30 p. m., Mathematics G08