



UNIVERSITY OF KARACHI

Department of Mathematics

MATH 685 • Astronomy I

Course Supervisor: Professor Dr. Syed Arif Kamal

Homepage: <http://ngds-ku.org/kamal> • e-mail: [kamal\(at the rate of\)ngds-ku.org](mailto:kamal(at the rate of)ngds-ku.org)

Time Allowed: 3 hours • Maximum Marks: 100 • Date: Friday, May 16, 2003

Student's Name _____ (in CAPITAL LETTERS using a "marker") • Paper Format A

Attempt **Question 1** and 5 other questions. Each part of **Question 1** is of 4 marks & of **Questions 2-7** is of 8 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	1c	1d	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	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 paper around, check if you have the back

page printed correctly. Last line of the second page is: <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 **Saturday, May 31, 2003 at 0900h**. 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) How does the rotation of earth round the sun produce different seasons? Explain with the help of a diagram.
- 1-b) List 2 assumptions *taken* in the modeling for '*g*' (acceleration due to gravity) and 2 assumptions *not taken* in the modeling.
- 1-c) In the following equation name the first, the second and the third term:

$$\mathbf{F}_{eff} = m \mathbf{a}_f - m \mathbf{w} \times (\mathbf{w} \times \mathbf{r}_R) - 2 m \mathbf{w} \times \mathbf{v}_R - m(d\mathbf{w}/dt) \times \mathbf{r}_R$$
- 1-d) Define the terms: flight-path angle, flight-direction angle, angle of attack, azimuth, angle of elevation, down-range error, cross-range error.
- 2-a) What is a GPS? Give some of its applications in communications, military operations and entertainment.
- 2-b) Show that two infinitesimal rotations commute by taking a specific example.
- 3-a) What is an ICBM, an IRBM, and an ABM. The recently fired '*Ghouri*' and '*Shaheen*' missiles by Pakistan fit under which of the above categories?
- 3-b) What is the major difference between the orbits of satellites and missiles. What is a polar satellite and a geostationary satellite. Give 2 applications of polar satellites.
- 4-a) Explain the terms navigation, guidance and control in the context of a targeted spacecraft by posing questions (*Where is the spacecraft currently located? On which path it should be moving? How to take the spacecraft to the desired path?*).
- 4-b) What is the major difference between a '*firecracker*' and a '*missile*'; a '*rocket engine*' and a '*jet-aircraft engine*'? Describe salient features of space program of Pakistan.
- 5-a) Compute the altitude (height from surface of earth) for a geostationary satellite in meters, given $G = 6.6720 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$, $M_E = 5.975 \times 10^{24} \text{ kg}$, $R_E = 6.37115 \times 10^6 \text{ m}$ (G is universal gravitational constant, M_E is mass of earth, R_E is radius of earth).
- 5-b) Compute the acceleration due to gravity as a function of distance from center of earth, $g(r)$, when $r < R_E$, $r > R_E$. Show that both converge to the same value as $r \rightarrow R_E$. If a cylindrical hole is dugged through the center of earth and a body dropped into the hole, compute the period of simple harmonic oscillation in seconds.
- 6-a) 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 '.
- 6-b) Obtain an expression of down-range error for surface-to-surface missile in Q. 6-a), if the flight-path angle changes from ' q ' to ' $q + Dq$ ' after t_1 seconds elapsed from time-of-launch.
- 7-a) What are the conventions to label x , y , z axes in an aircraft/rocket? What are the rotations about each of these axes called? What effects do they produce? Why does one introduce roll in the rocket?
- 7-b) Why an on-board computing system is preferred to telemetric control from ground? Describe one measure taken by the mathematician and one measure taken by the programmer to reduce the computing time of the data-processing system of INS (Inertial Navigation System).

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