quadratic form. The final two chapters develop the notion of a continuous and discontinuous function, the derivative of a function as the slope and the integral as the area under a curve. Among the physical problems which are formulated are problems of motion with respect to a moving reference frame, modes of vibration of a mass-spring system and problems in kinematics.

The book is well written and the presentation throughout achieves clarity of thought with a minimum of computational effort. The secondary-school teacher would do well to consult this book and to incorporate this material into his mathematics course as a supplement to, but not as a substitute for the more abstract mathematical topics now being offered.

Advances in the Astronautical Sciences, Volume 6. Meeting Proc. (New York, Jan. 1960). Horace Jacobs and Eric Burgess, eds. 898 pp. The Macmillan Co., New York, 1961. $25.00. *Reviewed by E. J. Öpik, University of Maryland.*

THREE days of meetings have produced an impressive collection of 57 technical papers on varied aspects of space flight, from celestial mechanics to biology, preceded by three policy-making or programming articles and a report on the proceedings of the panel discussion: "Man in Space, When?" (31 pp.), chiefly concerned with physiological hazards; the "when", however, remains unanswered.

Part 1 is concerned with space communications: demodulation methods, transmission efficiency, power supply and types of communication satellites.

Part 2 covers propulsion: the role of ion propulsion in load transfer between satellite orbits, to the Moon, and in manned flight to the planets, with payload and thrust data; ion sources for electrical propulsion, with melting, vaporization, and work-function tables for the metals concerned; application of nuclear rocket propulsion to interplanetary flight, with special consideration of Earth-Mars communication, radiation shielding of the crew, and control of the nuclear engine; straight-line flight conditions to Mars, with solar sail or electrical powerplant propulsion, the trip along a tangent line taking only about 100 days including escape and approach maneuvers, several times shorter than along the economical Hohmann orbits.

Part 3 discusses guidance and control: control of trajectory for landings on a planet having an atmosphere, with Earth to Mars example and wooden model; calculation of rendezvous and intercept conditions with a satellite; the equations of motion for attitude control of a rigid-body satellite; experimental investigation of attitude control by astronauts in simulated conditions—spin could be stopped in less than 10 seconds with an efficiency of 90 percent; theory of path control and errors in satellite rendezvous; mathematical analysis of the response to error disturbances in glider descent; trajectory predictions of the lost Lunik III, without sightings being available to substantiate theory; project of a fluorescence-phosphoresence P-7 detector for moving objects, which has a field of 30° and an estimated range of several thousand miles for vehicles of 2 feet in diameter; the feasibility of treating the motion of space probes by successive two-body approximations; a geocentric hyperbolic orbital arc within the sphere of action of the Earth, and a heliocentric elliptical arc outside it, in comparison with the more exact restricted three-body problem.

Part 4 treats problems of space medicine and astrobiology: life-preserving artificial cooling experiments with rats in hot environment (48–60°C); theoretical prediction of radiation dosages in passing the radiation belts; an account of unsuccessful experiments with biological material in Jupiter-rocket nose cones; a mathematical model of man's behavior (including "human caprice") in an *interstellar* station; systems of visual displays or auditory signals for guidance and information of astronauts; a system of soilless culture for space gardening, to provide eight different diets; experimental and theoretical studies of aerobic and anaerobic processing of human waste in closed self-sustained systems; experimental study of human factors in a long-range B-47 aircraft flight—after 36 hours of flight, 20 hours of rest were sufficient for full recovery toward active duty of test subjects, proving that "man is not the limiting factor in extended aerospace operation when properly designed equipment and biologistic support are adequately provided".

Part 5 deals with the relevant problems of celestial mechanics: orbital perturbations by an oblate Earth, with 22 pages of equations for accurate prediction of satellite positions; mathematical study of velocity impulses required in the beginning of a long coast to the target, to improve homing accuracy; rapid determination of orbital characteristics (without numerical integration) for intermediate elliptical orbits in landing maneuvers of a returning space craft; rapid and precise calculation (by numerical integration) of the relative motion of any two bodies in the solar system (e.g., motion of Venus relative to our Moon or a space craft, etc.); lunar theory as applied to the periodic trajectories of stable satellites, with application to a satellite of Venus having a period of about 3 months; the influence of gravity on the attitude, spin, and tumbling of an earth satellite; analytical solutions for motion and heat transfer in take-off or re-entry along a minor circle; minimum maneuver conditions for circularization of elliptic orbits; destructive effects from interstellar matter in travel at ultrahigh velocities approaching the speed of light ("the presence of matter in space effectively precludes the exploration . . . within a reasonable number of generations, of regions of space beyond a few hundred light years.").

Part 6 considers space vehicle design: radiator systems for the removal of heat from space vehicles; optimizing for total weight and volume of solar power plants; a new method for establishing exact gravity

and drag losses and optimization of multistage rocket designs; general discussion of reliability of space craft electronics, proposing exploitation of electrical and magnetic fields within films of molecular dimensions; a review of the capabilities and relative advantages of nuclear power plants, as compared with chemical and solar plants.

Part 7 is concerned with re-entry: the advantage of lithium vaporization as cooling agent, especially at leading structural edges of the re-entering space craft, as supported by simulator tests; a rapid nomographic method of selection of materials for ablating shields at re-entry; evaluation of cost of transporting materials to a lunar base—$700 per lb. in 1965, $3 per lb. in 1975!

Part 8 discusses various applications of astronautical systems: arrangement of orbits of satellite groupings and their optimization as to the area on the Earth's surface covered—determinate patterns are found to be preferable to probabilistic coverage; economic feasibility of propulsion by contained nuclear explosions—requires rockets of several thousand tons; calculation of material expenditure for placing a 3-ton vehicle into an orbit around Mars—with nuclear rocket from Earth the take-off weight is 60 tons, under optimal conditions; an automatic visual method for accurate tracking of space vehicles by photoelectric recording of the direction of the telescope and that of the observer's eye at the telescope; setting up of aims for a study of operational support of space vehicle missions.

Part 9, last but not least, is dedicated to space physics: expected radiation belts of Mars and Venus—the Martian satellite Phobos, by its "sweeping" effect, would provide a radiation-free base; estimate of nuclear radiation, indigenous and induced, at the lunar surface—300 millirems weekly in a steady state, and 10^5 during active Sun; the application of integral theorems of magnetohydrodynamics, instead of unobtainable full solutions, for numerical semiquantitative estimates of plasma behavior (however, no numerical applications are given); the effect of non-uniform magnetic fields on flow and heat transfer in an electrically conducting fluid, with numerical applications; the prospects of exploration of Jupiter and its system by space vehicles, based on a review of existing astrophysical knowledge and technical possibilities; a project of measuring the gravitational deflection of light near the solar limb to 0.01 sec of arc, either from a satellite, or a high-altitude balloon, with list of appropriate stars and estimates of photon background noise from the solar corona.

The articles are of a different degree of actuality, some of a purely "academic" character, such as those concerned with interstellar travel, others dealing directly with current problems of space rocketry. The contents of the volume are of great interest not only to those occupied with space probes, but also to those working in various branches of astrophysics and geophysics toward the exploration of the solar system.

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Future excellence in the field of spacecraft guidance and control is heavily dependent on research work conducted today. In recognition of this fact, an important activity at JPL is the Guidance and Control Research Section where an ideal environment is provided for individual research. Close association with outstanding physicists, both at JPL and at the Caltech Campus, wide breadth and scope of research work in diverse activities near at hand, and an unusual opportunity for organizing and equipping a laboratory for a specific research program are among the advantages provided to physicists interested in pursuing individual research. Areas of particular interest include the following:

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