23, the meteoroid is said to crumble "when it first encounters atmospheric resistance"; when is *first?* On the same page *m* stands for *n*. Atomic sputtering of a solid is not "smashing" (page 53). On Whipple's diagram of wind velocities, the wind has reversed its direction only once, not "5 times" (page 78) (there are five maxima and minima, without reversal). Velocities of separation for cometary fragments "of the order of a few kilometres per second" (page 115) are unthinkable. In the figure on page 126 the direction of motion of Jupiter is not indicated; if it is conventional (counterclockwise), the outcome will be a hyperbolic comet orbit, not an ellipse as shown; if it is clockwise, the most unusual (unrecorded) case of a retrograde short-period comet results as shown; also, "many successive perturbations" are *not* required—one could suffice.

There is an appendix containing "Review Questions and Problems" an average undergraduate would hardly master most of them on the evidence of this text alone; evidently, their difficulty has been recognized also by the author, who advises ignoring them "with impunity". There is no list of literature.

The reading of this, partly colloquial, exposition of meteor science definitely leaves the impression that the author has profound knowledge and experience in his subject. However, for the uninitiated it is a difficult kind of introduction to the maze of problems involved in the study of the stray bodies of the solar system.

SPACE TRAVEL IN 1901. The vehicle was a ride at the Niagara Falls Pan-American Exposition and gave customers a simulated trip to the moon.

Generations in transit

FLIGHT TO THE STARS. By James Strong. 178 pp. Hart, Hart, New York, 1965. $4.95.

by Herbert Malamud

When the first automobiles made their appearance, some critics of the noisy monsters tried to convince people that riders would not survive a velocity greater than sixty miles an hour. During the decade of the nineteen-thirties, science fiction stories treated in great detail the concept of space flight, ignoring those (including more than one otherwise competent scientist) who denounced space flight as impossible.

Now that we are perhaps five years from the moon, and it is clear that an extension to manned exploration of the planets is likely soon afterwards, we can still find those who circumscribe man's future. Doctor A will tell us that exploration is all very well, but clearly it is forever impossible for man to create permanent settlements on the inhospitable planets. Professor B will say that the planets are possible, but we can never reach the stars. Your reviewer is less dogmatic. I claim that it is impossible to light a safety match on a cake of wet soap. All else is possible.

Strong believes that it is possible to reach the stars, and he has written a book to proselytize his belief. In his words, "Only the madness of atomic war and total annihilation can bring the future to an end." His book, of necessity a mixture of science and science fiction, includes every argument he can muster to support his thesis, and destroys almost trivially several arguments against it.

The first section of Strong's book begins by admitting that we do not have a propulsion unit at present capable of driving a ship to the nearer stars in anything like a reasonable time. It discusses, without finding a "best solution," several drive concepts, including chemical, electrical, nuclear and thermonuclear rockets. Unknown concepts such as space warps, gravitation drives and faster-than-light travel are dismissed with short comments, since the unknown cannot be discussed in any detail. Since speeds greater than presently achieved rocket speeds are unknown, Strong avoids discussing them in detail. Instead, he uses a "speed growth" curve, plotting the highest speeds achieved by man over the last two hundred years or so, and extrapolating the curve past the present. Far fetched as it is, this reviewer agrees that this is the only course open to him.

Thus, he calculates that in a century, speeds of one percent of light speed may be expected, and 80 years later, five percent. This, he concludes, is about as far as he would want to trust the extrapolation of the speed growth curve, and, on the

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grounds that this is a reasonable maximum that may be expected from presently understood rocket systems, he stops there. A further reason for stopping at this point is the fact that a speed of five percent of that of light is sufficient to enable a star ship to reach the nearest stars in a time of the order of a century. Strong considers this to be reasonable for such a journey, but also feels that it is the maximum time that could be considered reasonable.

The only place where one might read of such journeys in ships outfitted to maintain a closed ecological system for a century or more is, so far as I know, in various science fiction stories, whose authors generally come to the conclusion that on a trip of over a century or so, the voyagers would lose sight of their purpose and degenerate into savagery. They also treat (in fiction) the possibility that voyagers on a journey that lasts too long would be met on arrival by others who started later, with ships developed in the meantime back on earth, capable of much higher speeds. These possibilities are said to limit a reasonable journey to a century or so. As Strong puts it, "Space writers take a gloomy view of the hazards within sealed star ships . . . (for very long trips)." He uses this as an argument that a century is a maximum for such a trip. I find this argument weak, since space writers are compelled to invent hazards. Else where is the story worth writing about?

Strong's ship then, is somewhat arbitrarily taken to be about three-quarters of a mile in length, with a mass of about 100 megatons of which 95% is fuel, and is to support 100 to 150 people for 100 years. Accessible space is thus a sphere of radius 20 light years. (This ship may be compared to one written about by Heinlein, some 20 or 30 years ago, which was five miles long and supported several hundred people for a century.)

Required power, thrust, etc. are analyzed and described. Strong then discusses the 55 stars to be found within 16 light years of the solar system, of which three are known to have, and four more suspected of having, unseen companions of planetary size.

Following this is a discussion of the possibilities of finding life on some of these stars, and a short discussion on the basics of attempting communication with alien life forms, both before and after a possible face-to-whatever meeting. Several books have appeared recently on the subject, some of which have gone into more detail than the present book. The discussion here is speculative, as it must be, but not unreasonable.

He concludes with speculation on the subject of why star travellers from elsewhere have not visited us recently.

I noted only two misstatements in reading the book. First, Pauli, and not Dirac, discovered/invented the neutrino. Second, although Strong was correct when he wrote that "not a single atom of antihydrogen has been created in the laboratory," he is no longer correct. Antideuterium was reported to have been created at Brookhaven [Phys. Rev. Letters, **14**, 1003 (1965)].

This book is an attempt to interest someone in the author's personal dream, that of stellar flight. If that "someone" should read it, Strong may succeed.

Results of instruction

SCIENCE TEACHING AND TESTING. By Leo Nedelsky. 368 pp. Harcourt, Brace and World, New York, 1965. $6.95.

by Robert L. Weber

Teachers and students of science are much indebted to Professor Nedelsky for his continuing crusade to persuade teachers to improve their own teaching and for his offering of tools effective in this task. He urges teachers to be more analytic about the goals of instruction and of conditions conducive to learning. A course may be analyzed in either of two ways: by observing teaching materials and processes and gauging them against an accepted standard or by measuring the students' achievement. The observation technique requires familiarity with theories of learning with respect to which "most college science teachers are ignorant, suspicious, belligerently defensive, and, when opportune, jubilantly offensive." For most of his exposition in this book, Nedelsky turns to the other technique, the measurement of how much students learn. "This technique, in principle . . ., is congenial to scientists, for it is largely empirical and can be readily mastered."

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The reviewer, who is a professor of physics at The Pennsylvania State University, is the author of a number of textbooks and has long been interested in methods of teaching science.

Essential to the measuring and judging of the results of instruction is a statement of desired results or objectives. Mere description of course content is inadequate. One needs to know what students are expected to be able to *do* with the content. In chapter 2, Nedelsky gives a list of possible objectives of a course in physical science. Three general types of competency (1) knowledge, (2) understanding (both analytical and intuitive) and (3) the ability to learn are subdivided using a simple decimal classification scheme employed throughout the book in relating sample questions, published tests, and bibliographies to specific course objectives. "This book, however, tries to avoid all—and especially semantic—coercion; its rhetoric is intended to make things clear and leave decisions to the reader."

Three chapters on teaching methods discuss (1) reading and analytical understanding, (2) disciplined and imaginative thinking and intuitive understanding, (3) the laboratory. There follow extensive chapters on tests: theory of testing, measuring understanding of science, forms of tests, preparing tests, uses of tests in diagnosis and research and annotated bibliographies. Part II, comprising 35% of the book, presents with comments sample tests for knowledge, tests for understanding, tests for ability to learn and laboratory performance tests.

The annotations in the bibliographies are not only helpful literature guides but often interesting comments. Under a listing of Jacques Barzun's *The House of Intellect* appears "Professor Barzun writes: 'Taking an objective test is simply pointing. It calls for the least effort of mind above that of keeping awake: recognition'." Ne-