cyclic group generated by c, then the generalized free product of F and $\{c\}$ with the amalgamation $c^2 = a^{-1}b^{-1}ab$ has a faithful representation in R. Consequently, G is a residually torsion-free nilpotent group. (Received July 5, 1963.)

603-149. E. R. SURYANARAYAN, Tyler Hall, University of Rhode Island, Kingston, Rhode Island. The geometry of Beltrami flows.

Beltrami flows are characterized by the fact that there exists a family of ∞^1 surfaces orthogonal to the stream lines. Each member of the family is a Beltrami surface. It is found that the Beltrami surfaces are orthogonal to the Bernoulli surfaces (which consist of stream lines and vortex lines) and the tangent plane at any point of the Beltrami surface contains the vorticity vector at that point. The mean curvature and the Gauss curvature of the Beltrami surfaces are expressed in terms of the flow quantities. Intrinsic equations of motion and continuity are obtained in the case when the Beltrami surfaces form a family of surfaces of revolution, the family of meridian curves being hyperbolas. From these intrinsic equations one gets examples of two special flows; one for isentropic flow of a polytropic gas and the other for fluid flow in the incompressible case. (Received July 5, 1963.)

603-150. D. H. CARLSON, 441 Virginia Terrace, Madison 5, Wisconsin. Inertial bounds for matrices.

Ostrowski and Schneider [J. Math. Anal. Appl., 1962] and Taussky [J. Soc. Indust. Appl. Math., 1961] have proved that, for any (complex) matrix A and any Hermitian matrix H, if $R(AH) = (AH + HA^*)/2$ is positive definite, then In H = In A. This conclusion does not hold, however, if it is required only that R(AH) be positive semi-definite (for example, if H = 0). Given the inertia of A, and the elementary divisor structure of its imaginary eigenvalues, bounds are obtained (which are best possible) for In H. If in addition the elementary divisor structure for the nonimaginary eigenvalues of A is given, best possible bounds are obtained for In H when R(AH) is positive semi-definite, of specified rank r. (Received July 5, 1963.)

603-151. F. W. LAWVERE, Reed College, Portland 2, Oregon. Functorial automata theory.

Given any small category $\mathfrak{C}$, e.g. the free category over a diagram, and any category $\mathcal{X}$, e.g., a category of finite algebras, the category $\mathcal{X}[\mathfrak{C}]$ of $\mathcal{X}$-automata over $\mathfrak{C}$ is defined; an object in $\mathcal{X}[\mathfrak{C}]$ is a functor A: $\mathfrak{C} \longrightarrow \mathcal{X}$ whose values at objects of $\mathfrak{C}$ are viewed as state-spaces and whose values at maps of $\mathfrak{C}$ are viewed as transitions, together with distinguished subspaces of admissible inputs and admissible outputs at each object of $\mathfrak{C}$. The class $P(\mathfrak{C})$ of all sets of maps in $\mathfrak{C}$ is a category with inclusions as the only maps, and a functor R: $\mathcal{X}[\mathfrak{C}] \longrightarrow P(\mathfrak{C})$ is defined so that, e.g., if $\mathfrak{C}$ is the free monoid on a finite alphabet and $\mathcal{X}$ is the category of finite sets, R(A) is the regular set of tapes accepted by A (Rabin and Scott, IBM Journal 3 (1959), 115-125) where A is any $\mathcal{X}$-automaton over $\mathfrak{C}$. Many effective operations on regular sets are shown to arise from functorial operations in $\mathcal{X}[\mathfrak{C}]$; for example, R is exact and the full subcategory of $\mathcal{X}[\mathfrak{C}]$ consisting of A such that R(A) is a subcategory of $\mathfrak{C}$ often has an adjoint to its inclusion. That every R(A) is "recursive" is shown effectively by factoring R through a category of Post-Smullyan objects. (Received July 5, 1963.)

603-152. W. T. KYNER, University of Southern California, Los Angeles 7, California. Orbits about an oblate planet. I.

The purpose of this paper is to establish the existence of a three parameter family of invariant manifolds in the phase space of the differential equations describing the motion of a satellite about an axisymmetric oblate planet. This is done by reducing the system of equations to third order by employing the two known integrals of the motion and then studying the trajectories in the three dimensional phase space. In this space, the trajectories fill an annulus. It follows from a theorem of J. Moser [On invariant curves of area-preserving mappings of an annulus, Nachr. Akad. Wiss. Gottingen. Math. Phys. Kl II (1962)] that the annulus is layered by invariant manifolds. Even though it is not known if these manifolds fill the annulus, their distribution is such that the stability of the orbits can be established. (Received July 5, 1963.)

603-153. JACOB BURLAK, New York University, New York 3, New York. Dual integral equations with Fourier kernels.

Dual integral equations of the form $\int_{-\infty}^{\infty}\phi(u)e^{-iux}du = f(x)$ $(x > 0)$, $\int_{-\infty}^{\infty}(\alpha + iu)^{\mu}(\beta + iu)^{\nu}\phi(u)e^{-iux}du = g(x)$ $(x < 0)$ are of interest in applications. The methods used hitherto to solve them explicitly (in special cases) have been ad hoc complex variable arguments or the Wiener-Hopf technique. A method of solution is presented which is akin to the 'elementary' method used successfully in the treatment of various dual integral equations with Hankel kernels. The essential idea is the use of an integral representation for ϕ which reduces the problem to a single integral equation. Three cases must be distinguished (i) $\mathrm{Re}(\alpha) > 0$, $\mathrm{Re}(\beta) > 0$; (ii) $\mathrm{Re}(\alpha) < 0$, $\mathrm{Re}(\beta) < 0$; (iii) $\mathrm{Re}(\alpha) < 0$, $\mathrm{Re}(\beta) > 0$. Case (ii) can be reduced to case (i) and the latter equations can be reduced to a form in which $f \equiv 0$: in this case the resulting integral equation is simply solved by the Mellin inversion theorem. Case (iii) is more troublesome but the solution can be obtained by superposition of the solutions when $f \equiv 0$ and $g \equiv 0$. (Received July 5, 1963.)

603-154. T. K. BOEHME, Mail Stop 74-86, Boeing Company, Renton, Washington. Approximate solutions to the convolution equation on the half-line.

A new proof is given of the following theorem of C. Foias (Studia Math. 21 (1961), 73-74). Theorem. If k is such that $\int_0^{\epsilon} |k|(t)dt > 0$ for every $\epsilon > 0$ the convolution equation $\int_0^t k(t - u)x(u)du = r(t)$ on the half-line $t > 0$ has an approximate solution for every locally integrable function r, in the sense that there is a sequence of locally integrable x_n such that the convolution $k * x_n$ tends to r in $L[0,T]$ for each $T > 0$ as n tends to infinity. The original proof was an existence proof only. The present proof shows how to construct such approximate solutions, when k is real, in terms of the characteristic values and characteristic functions of a completely continuous self-adjoint operator on a Hilbert space. (Received July 5, 1963.)