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Accurate Values of the Exponent Governing Potential Flow about Semi-Infinite Cones

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IT is well known that, for axisymmetric, inviscid, and incompressible flow about a semi-infinite cone, the velocity V on the surface of the cone varies with the distance s from the vertex in the following manner:

$$V = Cs^m \tag{1}$$

where C is simply a scaling constant. The flow is thus completely characterized by the exponent m, which is a function of Θ, the semivertex angle of the cone. Tabulated values of m do not appear to be readily available in the literature. Reference 1 gives a small graph of m vs Θ and also lists three references, including the original work of Ref. 2. However, none of the three is contained in ordinary technical libraries.

The equation relating m and Θ is

$$P_{m+1}'(-\cos\Theta) = 0 \tag{2}$$

where the prime denotes differentiation and the function P_{m+1} is the Legendre function that remains finite when its argument equals unity for all values of its order $m + 1$ (see Ref. 3). Using the series expansion of P_{m+1}, this equation was solved numerically for m at values of Θ ranging from 0° to 180° by 5° increments. The results are given in Table 1.

Table 1 Values of the exponent governing potential flow about semi-infinite cones

Θ, deg	m	Θ, deg	$1/m$
0	0.0000000	90	1.0000000
5	0.0037441	95	0.8779641
10	0.0145329	100	0.7715075
15	0.0316314	105	0.6779398
20	0.0544316	110	0.5951432
25	0.0825162	115	0.5214293
30	0.1156458	120	0.4554368
35	0.1537334	125	0.3960580
40	0.1968232	130	0.3423826
45	0.2450773	135	0.2936569
50	0.2987690	140	0.2492515
55	0.3582834	145	0.2086375
60	0.4241237	150	0.1713675
65	0.4969244	155	0.1370604
70	0.5774709	160	0.1053903
75	0.6667277	165	0.0760764
80	0.7658769	170	0.0488761
85	0.8763705	175	0.0235785
90	1.0000000	180	0.0000000

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Variable Collision Frequency Effects on Hall-Current Accelerator Characteristics

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Nomenclature

B = magnetic induction
b = ion-slip parameter
E = electric field
e = charge on electron
J = current density
L = reference length
M = Mach number
m = mass flow
m_a = atom mass
N = interaction parameter
P = pressure
S = parameter defined by Eq. (4)
T = temperature
V = velocity
z' = dimensionless axial coordinate = z/L
α = degree of ionization
β = Hall parameter defined by Eq. (5)
γ = specific heat ratio
η = energy conversion efficiency
ρ = mass density
σ = electrical conductivity
τ = time between collisions
$\bar{\tau}_e$ = mean electron collision time
ϕ = voltage difference between inlet and exit
ω = cyclotron frequency

Subscripts

ei = electron-ion collision
ea = electron-atom collision
ia = ion-atom collision
0 = accelerator inlet
z = axial direction
θ = azimuthal direction

ONE-dimensional magnetogasdynamic (MGD) analyses of the coaxial Hall-current accelerator have recently been presented by Brandmaier, Durand, Gourdine, and Rubel[1] and by Cann and Marlotte.[2] Each considered the steady continuum flow of an ideal, electrically neutral, slightly ionized, three-species gas mixture through a narrow constant

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