Typos and other items of interest in White's book on Viscous Fluid Flow

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Abstract

Professor White's book (2nd edition) is a good book. However, there are things said that are somewhat provocative, and some response seems appropriate. In addition, there are typos that could be bothersome. It is hoped that the following items are helpful to those who use this book either as a text or as a reference in the future.

Page 14: Fig. 1-13 shows a dimensional plot of experimental and computational data for one fluid mechanics problem. Since fluid mechanics is where dimensionless plots thrive, I used this plot as an example of what one should *not* do. If we assume that the experimental data and the computation were done for a problem with characteristic cross-section A, then the shown horizontal coordinate of this figure is proportional to a characteristic velocity U (by dividing it by A). The pressure drop (the vertical coordinate) should be non-dimensionalized by ρU^2 while the horizontal coordinate should be the Reynolds number (based on U and a characteristic length). Then the data so presented essentially says the non-dimensionalized pressure drop is a very weak function of the Reynolds number.

page 69: The energy equation derived by White is correct—provided **g** (the gravitational acceleration) is time-independent and there are no bona-fide body forces. If **g** is time-dependent (e.g. on a powered rocket ship), the derived equation is wrong. Most seriously, White gave the impression that the (external) *work* *done by body forces* need not be seriously considered—he only mentioned work done by surface forces. What happens when the fluid is electrically conducting and there are Lorentz forces in the momentum equation?

page 575: The formula for some of the strain rate tensor elements are missing a factor of 2.

page 218: Above and below Eq.(4-1): White says the (viscous) diffusion time is $\sqrt{\nu L/U^3}$—I am not kidding. Now this entity does have the physical dimension of time, but is it a good idea to call it the diffusion time? White's diffusion time, as defined, goes to zero in the limit as $\nu \rightarrow 0$. Normally, most people say diffusion time is the square of some length divided by ν—which goes to infinity in the same limit. Most people say the diffusion length is the square root of ν times time. A better way to do things, in my opinion, is to cancel out one U from both sides of the first equation in Eq.(4-1), and say "the diffusion length must be small compared to L, the characteristic length."

page 251: White did the Falkner-Skan solution, then said here that when $m = -1$ the Falkner-Skan solution is "inappropriate." It is easy to show that the inappropriateness can be removed by a simple transformation of the Falkner-Skan streamfunction and the η coordinate (get rid of the $m + 1$ factor by a simple transformation).

page 265: First sentence in §4-6.2: replace "subtract from" by "add to."

page 322: Fig. 4-49 should not give the impression that the divergence of vorticity can be violated—the net flux of vorticity of any closed surface in the flow field must be zero. One additional vortex is missing from the figure.

page 343: White did not sufficiently emphasize that the parallel basic flow (which is assumed for all classical stability analysis) does not satisfy Navier, Stokes, Prandtl or Newton. It is *ad hoc*.

page 351: White gave dimensionless "maximum temporal growth rate." Dimensional growth rate would be more physically meaningful.

page 392: In problem #5-6, White asked the second-order inviscid Orr-Sommerfeld ODE to be solved with full no-slip condition applied. Obviously a typo! In addition, White apparently wanted students to take the given U(η) profile from $\eta = 0$ to $\eta = 2$ where $u(\eta = 2) = 4U$—because he asked for a plot of c_i versus α. This is thus a very contrived problem (why did'nt he give a velocity profile that had an inflexion point inside $0 < y < \delta$?). If one interprets the given profile to have $u/U = 1$ for $y > \delta$, then by Rayleigh's Inflexion Point Theorem—which is bullet proof—we have $c_i = 0$, period! (actually, this conclusion remains valid even if we assume White wants his given profile to be valid between $\eta = 0$ to $\eta = 2$; see Theorem 3 on page 346 and Fig.5-4c on page 347) Plotting c_i versus α is boring. The interesting plot is c_r versus α.

page 419: Fig. 6-13 is supposed to be a plot of eq.(6-47) for $\delta^+ = 1000$. Now, Cole's formula says u^+ is logarithmically singular as $y^+ \to 0$. The graph says something else.

page 433: Bottom of page: Sec. 6-6.3 should be Sec. 6-6.2.

page 444: In White's description of the one-equation model, the turbulent eddy viscosity is not mentioned. Neither is the initial condition for K.

page 445: On the two-equation model: What about initial and boundary conditions for ϵ?

page 450: The exponent 0.268 in eq.(6-118) has the wrong sign.

page 505: Eq.(7-20) is only valid if $d \ln U_e / d \ln \xi$ is not ξ-dependent and if ρ_e/ρ is somehow accommodating to the same requirement (e.g via Busemann's integral). This is the reason for White to say it is "more or less" an ordinary differential equation.

page 506: Eq.(7-27) is only correct if f has no dependence on ξ—strictly speaking.

page 529: Eq.(7-75) has two typos. The factor of the middle term on the left hand side should be $(1 + 2\alpha^*/P_r)$ (the sign was wrong), and the denominator of the third term on the right hand side should not contain u.

Of course, this is by no means a complete list. It is just a summary of what we found.

Some of the typos and errors were found by students.