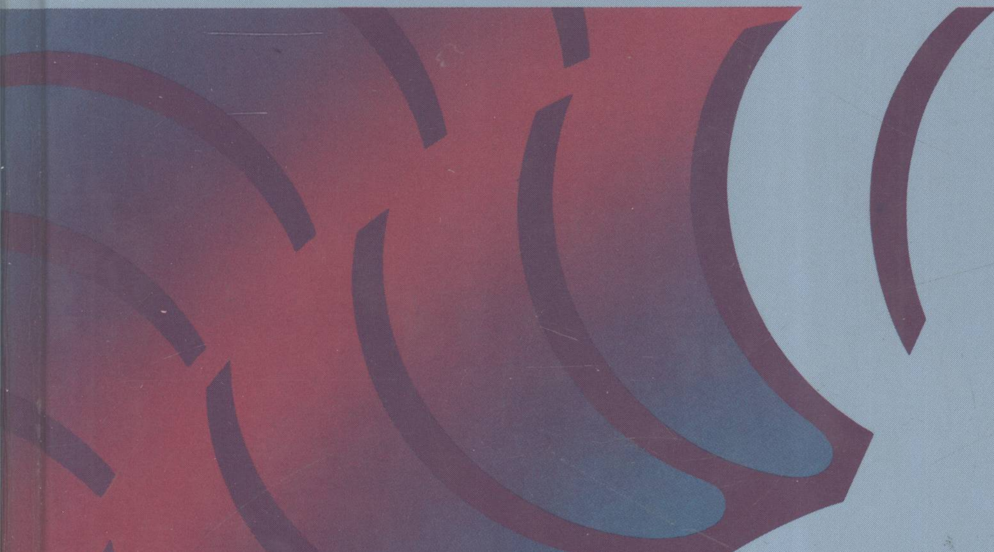
APPLIED

FLUID MECHANICS



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to
Jane

Preface

In many undergraduate engineering programs, students from all disciplines take a one-semester course in fluid mechanics in the first or second year of study. For some branches, this is the only course in fluids, whereas for students in other branches, such as mechanical, chemical, and civil engineering, this introductory course precedes a series in turbomachinery, gas dynamics, and hydraulics. Thus, an introductory course should give an understanding of a reasonably wide variety of topics encountered in engineering practice, while concurrently laying a good foundation for further analytical development by those pursuing the higher level fluids courses.

In the present text, topics are handled with analyses that are rigorous, but without the formality of more extensive works. The various concepts are illustrated with the use of sample problems of graduated complexity and, where relevant, the nature and importance of the assumptions involved are discussed. The latter element is of considerable importance, because engineering students should be made aware of the difference between "textbook" solutions, and what should be the "real" results.

An effort has been made to make this text as readable as possible, and in areas which students often find troublesome, the work is dealt with as simply and straightforwardly as the demands of the material allow.

Optional topics are covered in Appendices C and D, and may be omitted without loss of continuity.

In Appendix C, the analysis of the emptying of a cylindrical tank is extended to various other geometries. This part of the text may be included either as an exercise in determining tank flux rates, or as an illustration of flow through a drain pipe with friction loss.

Appendix D provides the reader with programs to assist in the solution of various problems in the text. These programs are not absolutely essential, but "manual" solutions or solutions assisted by a programmable hand calculator will be very tedious.

Boundary layer theory is introduced in Chapter 6. The coverage is elementary but will provide a bridge to more advanced topics for those students who will proceed to further courses in fluid mechanics.

The subjects of this text are designed to be covered in a one-semester course, or in a more leisurely two semesters. The duration will depend, to a large degree, on the emphasis placed by the instructor on topics in Chapter 5. For example, an in-depth coverage of programmed solutions for pipe network problems will demand considerable time.

The prerequisites for students using this text should include:

(a) an introductory course in statics;
(b) a first calculus course.

A computer programming course (Fortran, Basic) would be useful but not essential.

In keeping with Canada's metrication plans, the Système International d'Unités (S.I.) is used throughout this book. Students who want information about conversions to other unitary systems, or values of physical constants not supplied here, may consult a reference text such as Kaye (1982).

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Nomenclature

a	dimension, acceleration, acoustic velocity, constant
a_x, a_y	components of acceleration
A, δA	area, element of area
b	dimension, constant
C	Hazen-Williams roughness coefficient
C_1, C_2	constants
C_d	local drag coefficient
C_D	average drag coefficient
C_L	lift coefficient
C_p	coefficient of pressure
d	dimension, diameter
D_f	drag force
D_h	hydraulic diameter
dF_t	upper elemental force
dF_u	lower elemental force
$d\mathcal{V}_t$	upper elemental volume
$d\mathcal{V}_u$	lower elemental volume
Eu	Euler number

f	frequency of oscillation, friction factor, mathematical function
F	force, nondimensional flowrate
Fr	Froude number
g	acceleration due to gravity
h	dimension
h_f	friction head loss
h_L	hydraulic head loss
h_m	minor head loss
h_p	pump head rise
H	nondimensional height
$\boldsymbol{H}$	moment of momentum
$\boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k}$	unit vectors along x,y,z directions
I	second moment of area, mass
$\bar{I}$	centroidal second moment of area, second moment of mass about an axis through the mass centre
I_{cxy}	centroidal product of inertia
I_{Oxy}	product of inertia about axes Ox and Oy
k	diameter ratio, ratio of specific heats
K	bulk modulus of elasticity, coefficient in friction loss equation, loss coefficient for a pipe fitting
ℓ	dimension
ℓ_e	equivalent length
L	dimension, basic dimension of length, nondimensional length
$\boldsymbol{L}$	linear momentum
L_D	development length
L_f	lift force
m	mass
$\dot{m}$	mass flowrate
M	basic dimension of mass; Mach number
$\boldsymbol{M}$	couple
n	polytropic index
N	extensive property, rotational speed in r/min
p	pressure
$\Delta p/\ell$	pressure gradient
P	perimeter
Q	volume flowrate

r	radial dimension
$\mathbf{r}$	radial displacement vector
R	dimension, gas constant
Re	Reynolds number
s	dimension, streamline direction
S	slope of hydraulic grade line
SG	specific gravity
t	time
t_p	period of oscillation
T	nondimensional time, basic dimension of time
$\mathbf{T}$	torque
$u, v, w,$	velocity components
$\overline{u}$	mean turbulent flow speed
U	boundary speed
U_∞	free stream speed
$\mathbf{v}, \mathbf{V}$	velocity; local, average
V	average speed
$\mathcal{V}$	volume
v_s	volume per unit mass
w	dimension
W	weight
We	Weber number
$x, y, z,$	rectangular coordinates
x_{cp}, y_{cp}	coordinates of centre of pressure
$\overline{x}, \overline{y}$	centroidal coordinates
α	angle, kinetic energy correction factor
β	angle, linear momentum correction factor
γ	specific weight
Δ	step length
∇	divergence operator
δ	boundary layer thickness
ϵ	roughness
η	eddy viscosity, intensive property
θ	angle
μ	absolute viscosity
ν	kinematic viscosity
Π	nondimensional group
ρ	density

σ	surface tension
τ	shear stress
ϕ	angle
ω	rotational speed in rad/s
Note:	In this text, all dimensions given without units are in millimetres.

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