## Contents

	ABOU	JT THE AUTHORS	viii	
	PREFACE			
	LIST	OF SYMBOLS	xi	
1	<b>HIST</b> (	<b>DRY OF FLUID MECHANICS</b> Fluid mechanics in everyday life	<b>1</b> 1	
	1.2	The beginning of fluid mechanics	1	
2	CHAI	RACTERISTICS OF A FLUID	6	
	2.1	Fluid	6	
	2.2	Units and dimensions	0	
	2.3	Density, specific gravity and specific volume	0	
	2.4	VISCOSILY	13	
	2.5	Compressibility	16	
	2.0	Characteristics of a perfect gas	17	
	2.8	Problems	18	
3	FLUII	D STATICS	20	
	3.1	Pressure	20	
	3.2	Forces acting on the vessel of liquid	30	
	3.3	Why does a ship float?	33	
	3.4	Relatively stationary state	50	
	3.5	Problems	31	
4	FUN	DAMENTALS OF FLOW	41	
_	4.1	Streamline and stream tube	41	
	4.2	Steady flow and unsteady flow	43	
	4.3	Three-dimensional, two-dimensional and one-dimensional flow	43	
	4.4	Laminar flow and turbulent flow	44	
	4.5	Keynolds number	40 46	
	4.0 17	Rotation and spinning of a liquid	40	
	- <del>1</del> ./ 4.8	Circulation	50	
	4.9	Problems	53	

5 ONE	ONE-DIMENSIONAL FLOW: mechanism for conservation of				
flow	properties	55			
5.1	Continuity equation	55			
5.2	Conservation of energy	56			
5.3	Conservation of momentum	70			
5.4	Conservation of angular momentum	76			
5.5	Problems	78			
6 FLO	W OF VISCOUS FLUID	82			
6.1	Continuity equation	82			
6.2	Navier-Stokes equation	83			
6.3	Velocity distribution of laminar flow	88			
6.4	Velocity distribution of turbulent flow	94			
6.5	Boundary layer	101			
6.6	Theory of lubrication	106			
6.7	Problems	109			
7 FLO	W IN PIPES	111			
7.1	Flow in the inlet region	112			
7.2	Loss by pipe friction	114			
7.3	Frictional loss on pipes other than circular pipes	118			
7.4	Various losses in pipe lines	119			
7.5	Pumping to higher levels	132			
7.6	Problems	134			
8 FLO	W IN A WATER CHANNEL	136			
8.1	Flow in an open channel with constant section and				
	flow velocity	136			
8.2	Best section shape of an open channel	138			
8.3	Specific energy	141			
8.4	Constant discharge	142			
8.5	Constant specific energy	143			
8.6	Constant water depth	143			
8.7	Hydraulic jump	144			
8.8	Problems	146			
9 DRA	AG AND LIFT	148			
9.1	Flows around a body	148			
9.2	Forces acting on a body	149			
9.3	The drag of a body	149			
9.4	The lift of a body	161			
9.5	Cavitation	167			
9.6	Problems	169			
10 DIN	IENSIONAL ANALYSIS AND LAW OF SIMILARITY	171			
10.	Dimensional analysis	171			
10.2	2 Buckingham's $\pi$ theorem	172			
10.3	3 Application examples of dimensional analysis	172			
10.4	4 Law of similarity	175			
10.:	5 Problems	180			

11	MEASUREMENT OF FLOW VELOCITY AND FLOW RATE	182
	11.1 Measurement of flow velocity	182
	11.2 Measurement of flow discharge	186
	11.3 Problems	195
12	FLOW OF AN IDEAL FLUID	197
	12.1 Euler's equation of motion	197
	12.2 Velocity potential	198
	12.3 Stream function	200
	12.4 Complex potential	201
	12.5 Example of potential flow	203
	12.6 Conformal mapping	212
	12.7 Problems	216
13	FLOW OF A COMPRESSIBLE FLUID	218
	13.1 Thermodynamical characteristics	218
	13.2 Sonic velocity	221
	13.3 Mach number	223
	13.4 Basic equations for one-dimensional compressible flow	224
	13.5 Isentropic flow	226
	13.6 Shock waves	230
	13.7 Fanno flow and Rayleigh flow	235
	13.8 Problems	236
14	UNSTEADY FLOW	238
_	14.1 Vibration of liquid column in U-tube	238
	14.2 Propagation of pressure in pipe line	240
	14.3 Transitional change in flow quantity in a pipe line	242
	14.4 Velocity of pressure wave in a pipe line	243
	14.5 Water hammer	244
	14.6 Problems	247
15	COMPUTATIONAL FLUID DYNAMICS	249
	15.1 Finite difference method	249
	15.2 Finite volume method	262
	15.3 Finite element method	264
	15.4 Boundary element method	269
16	FLOW VISUALISATION	274
	16.1 Classification of techniques	274
	16.2 Experimental visualisation methods	274
	16.3 Computer-aided visualisation methods	286
	ANSWERS TO PROBLEMS	291
	INDEX	299