

CONTENTS

Preface	xvii
Acknowledgments	xviii
List of figures	xxiii
List of tables	xxvi
I Introduction	1
1 The Scope	3
1.1 Engineering	4
1.2 Aerospace activity	5
1.3 Aviation research agenda	12
1.3.1 Challenges	12
1.3.2 Clean Sky	13
1.3.3 SESAR	15
References	17
2 Generalities	19
2.1 Classification of aerospace vehicles	20
2.1.1 Fixed wing aircraft	21
2.1.2 Rotorcraft	23
2.1.3 Missiles	24
2.1.4 Space vehicles	25
2.2 Parts of the aircraft	27
2.2.1 Fuselage	27
2.2.2 Wing	28
2.2.3 Empennage	30
2.2.4 Main control surfaces	31
2.2.5 Propulsion plant	32

2.3	Standard atmosphere	33
2.3.1	Hypotheses	33
2.3.2	Fluid-static equation	34
2.3.3	ISA equations	34
2.3.4	Warm and cold atmospheres	36
2.3.5	Barometric altitude	37
2.4	System references	37
2.5	Problems	39
	References	43
II	The aircraft	45
3	Aerodynamics	47
3.1	Fundamentals of fluid mechanics	48
3.1.1	Generalities	48
3.1.2	Continuity equation	49
3.1.3	Quantity of movement equation	50
3.1.4	Viscosity	52
3.1.5	Speed of sound	56
3.2	Airfoils shapes	58
3.2.1	Airfoil nomenclature	59
3.2.2	Generation of aerodynamic forces	60
3.2.3	Aerodynamic dimensionless coefficients	63
3.2.4	Compressibility and drag-divergence Mach number	66
3.3	Wing aerodynamics	68
3.3.1	Geometry and nomenclature	68
3.3.2	Flow over a finite wing	69
3.3.3	Lift and induced drag in wings	71
3.3.4	Characteristic curves in wings	72
3.3.5	Aerodynamics of wings in compressible and supersonic regimes	73
3.4	High-lift devices	74
3.4.1	Necessity of high-lift devices	74
3.4.2	Types of high-lift devices	75
3.4.3	Increase in $\hat{C}_{L_{max}}$	77
3.5	Problems	79
	References	101
4	Aircraft structures	103
4.1	Generalities	104
4.2	Materials	108

4.2.1	Properties	108
4.2.2	Materials in aircraft	109
4.3	Loads	113
4.3.1	Fuselage loads	113
4.3.2	Wing and tail loads	114
4.3.3	Landing gear loads	114
4.3.4	Other loads	114
4.4	Structural components of an aircraft	114
4.4.1	Structural elements and functions of the fuselage	115
4.4.2	Structural elements and functions of the wing	117
4.4.3	Tail	118
4.4.4	Landing gear	118
	References	119
5	Aircraft instruments and systems	121
5.1	Aircraft instruments	122
5.1.1	Sources of data	123
5.1.2	Instruments requirements	126
5.1.3	Instruments to be installed in an aircraft	126
5.1.4	Instruments layout	130
5.1.5	Aircrafts' cockpits	131
5.2	Aircraft systems	135
5.2.1	Electrical system	135
5.2.2	Fuel system	137
5.2.3	Hydraulic system	139
5.2.4	Flight control systems: Fly-By-Wire	140
5.2.5	Air conditioning & pressurisation system	142
5.2.6	Other systems	143
	References	145
6	Aircraft propulsion	147
6.1	The propeller	148
6.1.1	Propeller propulsion equations	148
6.2	The jet engine	150
6.2.1	Some aspects about thermodynamics	151
6.2.2	Inlet	153
6.2.3	Compressor	154
6.2.4	Combustion chamber	156
6.2.5	Turbine	158
6.2.6	Nozzles	160
6.3	Types of jet engines	162

6.3.1	Turbojets	162
6.3.2	Turbofans	164
6.3.3	Turboprops	165
6.3.4	After-burning turbojet	166
References	. . . . .	167
7	Mechanics of flight	169
7.1	Performances	170
7.1.1	Reference frames	170
7.1.2	Hypotheses	170
7.1.3	Aircraft equations of motion	172
7.1.4	Performances in a steady linear flight	175
7.1.5	Performances in steady ascent and descent flight	175
7.1.6	Performances in gliding	176
7.1.7	Performances in turn maneuvers	177
7.1.8	Performances in the runway	179
7.1.9	Range and endurance	182
7.1.10	Payload-range diagram	184
7.2	Stability and control	187
7.2.1	Fundamentals of stability	187
7.2.2	Fundamentals of control	189
7.2.3	Longitudinal balancing	191
7.2.4	Longitudinal stability and control	192
7.2.5	Lateral-directional stability and control	194
7.3	Problems	196
References	. . . . .	229
III	Air Transportation, Airports, and Air Navigation	231
8	Air transportation	233
8.1	Regulatory framework	234
8.1.1	ICAO	234
8.1.2	IATA	239
8.2	The market of aircraft for commercial air transportation	240
8.2.1	Manufacturers in the current market of aircraft	241
8.2.2	Types of aircraft	243
8.2.3	Future market of aircraft	245
8.3	Airlines' cost structure	247
8.3.1	Operational costs	248
8.4	Environmental impact	256

8.4.1	Sources of environmental impact	256
8.4.2	Aircraft operations' environmental fingerprint.	257
References	. . . . .	268
9	Airports	269
9.1	Introduction	270
9.1.1	Airport designation and naming	270
9.1.2	The demand of air transportation	271
9.1.3	The master plan	273
9.2	Airport configuration	273
9.2.1	Airport description	273
9.2.2	The runway	276
9.2.3	The terminal	282
9.2.4	Airport services	287
9.3	Airport operations	288
9.3.1	Air Traffic Management (ATM) services	288
9.3.2	Airport navigational aids	289
9.3.3	Safety management	295
9.3.4	Environmental concerns	295
References	. . . . .	297
10	Air navigation	299
10.1	Introduction	300
10.1.1	Definition	300
10.1.2	History	300
10.2	Technical and operative framework	306
10.2.1	Communications, Navigation & Surveillance (CNS)	306
10.2.2	Air Traffic Management (ATM)	308
10.3	Airspace Management (ASM)	311
10.3.1	ATS routes	311
10.3.2	Airspace organization in regions and control centers	314
10.3.3	Restrictions in the airspace	316
10.3.4	Classification of the airspace according to ICAO	317
10.3.5	Navigation charts	317
10.3.6	Flight plan	321
10.4	Technical support: CNS system	321
10.4.1	Communication systems	322
10.4.2	Navigation systems	325
10.4.3	Surveillance systems	343
10.5	SESAR concept	348
10.5.1	Single European Sky	348

10.5.2	SESAR	348
References	. . . . .	349
IV	Appendixes	351
A	6-DOF Equations of Motion	353
A.1	Reference frames	354
A.2	Orientation between reference frames	355
A.2.1	Wind axes-Local horizon orientation	357
A.2.2	Body axed-Wind axes orientation	358
A.3	General equations of motion	358
A.3.1	Dynamic relations	358
A.3.2	Forces acting on an aircraft	360
A.4	Point mass model	361
A.4.1	Dynamic relations	361
A.4.2	Mass relations	362
A.4.3	Kinematic relations	362
A.4.4	Angular kinematic relations	364
A.4.5	General differential equations system	364
References	. . . . .	367
Index		374