

# Table of contents

<b>References</b>	<b>xiv</b>
<b>List of figures</b>	<b>xvii</b>
<b>List of tables</b>	<b>xxiii</b>
<b>Nomenclature</b>	<b>xxv</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Importance of aeroelasticity for an efficient world . . . . .	1
1.2 Motivation and objectives . . . . .	5
1.3 Structure of the work . . . . .	6
<b>References</b>	<b>7</b>
<b>2 Fundamentals of fluid-structure interaction</b>	<b>11</b>
2.1 Introduction to the fluid-structure interaction . . . . .	11
2.2 Fundamentals of elasticity . . . . .	13
2.3 Fundamentals of fluid mechanics . . . . .	15
2.4 Introduction to the aeroelastic phenomena: instabilities . . . . .	16
2.4.1 Static instability: divergence . . . . .	18
2.4.2 Linear dynamic instability: flutter . . . . .	20
2.4.3 Nonlinear dynamic instability: stall flutter . . . . .	22
<b>References</b>	<b>23</b>
<b>3 Computational simulation of aeroelastic phenomena</b>	<b>27</b>
3.1 Introduction to the computational simulation . . . . .	27
3.2 Three-dimensional simulation of aeroelastic phenomena . . . . .	30
3.2.1 Computational fluid dynamics: CFD . . . . .	30

3.2.2	Finite elements analysis: FEA . . . . .	38
3.2.3	Fluid structure interaction: FSI . . . . .	43
3.3	Reduced order models . . . . .	45
3.3.1	Aerodynamic models . . . . .	45
3.3.2	Artificial Neural Networks for nonlinear flow predictions . . . . .	55
3.3.3	Structural models . . . . .	61
3.3.4	Reduced order model for generic aeroelastic phenomena . . . . .	78
<b>References</b>		<b>105</b>
<b>4</b>	<b>Results</b>	<b>111</b>
4.1	Introduction to the results . . . . .	111
4.2	Dimensional reduction of a clamped squared-section beam to a mass-spring system . . . . .	112
4.2.1	Problem description . . . . .	112
4.2.2	Bi-dimensional simulated aerodynamics . . . . .	114
4.2.3	Bi-dimensional ANN surrogate aerodynamics . . . . .	131
4.3	Application of beam theory to elastic structures . . . . .	146
4.3.1	Validation of the beam element solver . . . . .	146
4.3.2	Orthotropic 1D squared cross-section beam clamped by one edge. . . . .	148
4.3.3	Orthotropic wind turbine blade. . . . .	160
4.3.4	Flexible membrane semi-monocoque wing. . . . .	174
<b>References</b>		<b>190</b>
<b>5</b>	<b>Conclusions and future work</b>	<b>195</b>
5.1	Conclusions . . . . .	195
5.2	Future works . . . . .	198
<b>References</b>		<b>199</b>
<b>References</b>		<b>201</b>