

---

# Contents

---

<b>Foreword</b> . . . . .	ix
<b>Preface</b> . . . . .	xi
<b>Introduction</b> . . . . .	xv
<b>Chapter 1. Motorization and Reflection on Ideal Engines</b> . . . . .	1
1.1. Motorization for an aircraft . . . . .	1
1.1.1. Helicopters . . . . .	1
1.1.2. Aircraft . . . . .	19
1.1.3. Compound formulas . . . . .	22
1.2. Motorization for an automobile . . . . .	25
1.2.1. Determining tractive force and useful power . . . . .	25
1.2.2. Definition of ideal transportation powertrain . . . . .	30
1.3. Conclusion . . . . .	33
<b>Chapter 2. Engine Technologies</b> . . . . .	35
2.1. Introduction . . . . .	35
2.2. Gas turbines . . . . .	36
2.2.1. General operating principles . . . . .	36
2.2.2. Improvement of gas turbines . . . . .	79
2.3. Electric motors . . . . .	87
2.3.1. Introduction to electric motors . . . . .	87
2.3.2. Use of electric motors and mission profile . . . . .	93
2.3.3. Electric motor technologies for propulsion . . . . .	101
2.3.4. Examples of specific propulsion systems and applications . . . . .	105

2.4. Internal combustion engine pistons . . . . .	111
2.4.1. Theoretical thermodynamic cycles . . . . .	111
2.4.2. Real cycles . . . . .	128
2.5. Conclusion . . . . .	142
<b>Chapter 3. Power Transmission Elements . . . . .</b>	<b>145</b>
3.1. Transmission system for rotating wings . . . . .	145
3.1.1. Conventional helicopters . . . . .	145
3.1.2. The case of multi-rotor structures . . . . .	151
3.2. Transmission system for aircraft . . . . .	152
3.2.1. Propeller aircraft cases . . . . .	152
3.2.2. Turbojet aircraft . . . . .	153
3.3. Transmission system for the automotive industry . . . . .	154
3.3.1. Gasoline or diesel internal combustion engines . . . . .	154
3.3.2. The case of electric motors . . . . .	167
3.4. Conclusion . . . . .	168
<b>Chapter 4. Energy Storage . . . . .</b>	<b>171</b>
4.1. Classification of energy sources . . . . .	171
4.1.1. Primary energy sources . . . . .	171
4.1.2. Energy carrier concept . . . . .	173
4.1.3. Use of different energy sources in automotive and aeronautical transport . . . . .	174
4.2. Energy storage for transport . . . . .	178
4.2.1. Different forms of energy storage . . . . .	178
4.2.2. Different energy storage technologies . . . . .	179
4.3. Forms of hydrogen storage . . . . .	186
4.3.1. Storage in gaseous form . . . . .	187
4.3.2. Storage in liquid form . . . . .	188
4.3.3. Storage in solid form . . . . .	189
4.3.4. Comparison of diesel fuel tanks and automotive batteries . . . . .	213
4.4. Conclusion . . . . .	217
<b>Chapter 5. Hybridization . . . . .</b>	<b>219</b>
5.1. Hybridization of electric motors: range extender . . . . .	221
5.1.1. Application examples for the automotive industry . . . . .	222
5.1.2. Application examples for aeronautics . . . . .	229
5.2. Hybridization of combustion engines: improving energy efficiency . . . . .	232

5.2.1. Interest in parallel hybridization . . . . .	232
5.2.2. Classification of electrical hybridization: the case of the automobile . . . . .	234
5.2.3. Implementation of hybridization in the case of the automobile . . .	255
5.3. Conclusion . . . . .	263
<b>References</b> . . . . .	265
<b>Index</b> . . . . .	269