

SELECTED TOPICS In Aerospace Engineering

EDITOR

ERWIN SULAEMAN



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TABLE OF CONTENT

| | |
|----------------------------------|-------------|
| PREFACE..... | i |
| TABLE OF CONTENT..... | iii |
| CONTRIBUTING AUTHORS..... | xiii |

PART I

| | |
|---|----------|
| <i>FUNDAMENTAL COMPRESSOR FOR AIRCRAFT'S TURBO ENGINES</i> | 1 |
|---|----------|

| | |
|-----------------------------|----------|
| <i>NOMENCLATURE.</i> | 2 |
|-----------------------------|----------|

CHAPTER ONE

| | |
|--|----------|
| <i>INTRODUCTION TO COMPRESSORS.</i> | 4 |
|--|----------|

| | |
|------------------|---|
| 1.1 Introduction | 4 |
|------------------|---|

| | |
|--------------------------|---|
| 1.2 Types of Compressors | 4 |
|--------------------------|---|

| | |
|---|---|
| 1.2.1 Positive Displacement Compressors | 4 |
|---|---|

| | |
|---------------------------|---|
| 1.2.2 Dynamic Compressors | 4 |
|---------------------------|---|

| | |
|------------------------------------|---|
| 1.3 Comparison of Compressor Types | 5 |
|------------------------------------|---|

| | |
|----------------|---|
| 1.31 Flow rate | 5 |
|----------------|---|

| | |
|------------------|---|
| 1.3.2 Efficiency | 6 |
|------------------|---|

| | |
|----------------------|---|
| 1.3.3 Pressure Ratio | 7 |
|----------------------|---|

| | |
|-----------------------------|---|
| 1.3.4 Characteristic Curves | 7 |
|-----------------------------|---|

CHAPTER TWO

| | |
|--|----|
| <i>TWO-DIMENSIONAL ANALYSIS OF COMPRESSORS.</i> | 9 |
| 2.1 Velocity diagrams of the compressor stage | 10 |
| 2.2 Thermodynamics of the compressor stage | 10 |
| 2.3 Stage loss and efficiency | 11 |
| 2.4 Reaction ratio | 12 |
| 2.5 Stage loading | 13 |

CHAPTER THREE

| | |
|--|----|
| <i>THREE-DIMENSIONAL ANALYSIS OF COMPRESSORS.</i> | 15 |
| 3.1 Theory of radial equilibrium | 15 |
| 3.2 Free-vortex flow | 16 |
| 3.3 Forced vortex | 18 |
| 3.4 General whirl distribution | 18 |

CHAPTER FOUR

| | |
|--|----|
| <i>ROTATING STALL AND SURGE.</i> | 20 |
| 4.1 Performance of Axial and Radial Compressors | 20 |
| 4.2 Aerodynamic Flow Instabilities | 22 |
| 4.2.1 Rotating stall | 23 |
| 4.2.2 Surge | 24 |
| 4.2.3 Rotating Stall and Surge in Radial Compressors | 26 |

CHAPTER FIVE

| | |
|--|----|
| <i>MODELING OF COMPRESSION SYSTEMS.</i> | 27 |
| 5.1 Introduction | 27 |
| 5.2 Greitzer lumped parameter model | 28 |

CHAPTER SIX

| | |
|----------------------------------|----|
| <i>COMPRESSOR MODELS.</i> | 34 |
|----------------------------------|----|

| | | |
|-----|----------------------|----|
| 6.1 | Moore Model | 34 |
| 6.2 | Moore-Greitzer model | 36 |

CHAPTER SEVEN

SURGE AND ROTATING STALL. 40

| | | |
|-----|-------------------------------------|----|
| 7.1 | Stability of compression systems | 40 |
| 7.2 | Control of Surge and Rotating Stall | 41 |
| 7.3 | Avoidance Control | 41 |
| 7.4 | Active Control | 44 |

REFERENCE OF PART I. 46

PART II

RIGID-BODY DYNAMICS OF AIR VEHICLE 48

CHAPTER EIGHT

AIRCRAFT RIGID-BODY EQUATION OF MOTIONS: A NONLINEAR MODEL

| | | |
|-----|-------------------------------|----|
| 8.1 | Introduction | 49 |
| 8.2 | Definition of Axes and Angles | 49 |
| 8.3 | The Rigid-Body Equations | 52 |
| 8.4 | Conclusions | 55 |

CHAPTER NINE

AIRCRAFT EQUATIONS OF MOTIONS: A NONLINEAR MODEL

| | | |
|-----|--|----|
| 9.1 | Introduction | 57 |
| 9.2 | Orientation and Position of the Airplane | 57 |
| 9.3 | Euler's Equations of Motion | 59 |
| 9.4 | Effect of Spinning Rotors | 60 |
| 9.5 | The Collected Equations | 61 |

| | | |
|-----|-------------|----|
| 9.6 | Conclusions | 62 |
|-----|-------------|----|

CHAPTER TEN

AIRCRAFT EQUATIONS OF MOTION: A LINEAR MODEL

| | | |
|------|------------------------------|----|
| 10.1 | Introduction | 63 |
| 10.2 | The Small-Disturbance Theory | 63 |
| 10.3 | Conclusions | 69 |

REFERENCE OF PART II 70

PART III

DYNAMICS OF FLEXIBLE STRUCTURE OF AIR

VEHICLE 71

NOMENCLATURES 72

CHAPTER ELEVEN

OVERVIEW OF DYNAMICS OF FLEXIBLE AIR VEHICLE 76

| | | |
|------|---|----|
| 11.1 | Introduction | 76 |
| 11.2 | The Influence of the Structural Flexibility on Vehicle Design | 76 |
| 11.3 | Non-uniform Beam Finite Element | 77 |
| 11.4 | Aerodynamic Discrete Element Methods | 79 |
| 11.5 | The doublet lattice method (DLM) | 79 |
| 11.6 | The doublet point method (DPM) | 80 |
| 11.7 | Conclusions | 81 |

CHAPTER TWELVE

TRANSLATION OF AXIS PROCEDURE TO CONSTRUCT STIFFNESS MATRIX

| | | |
|------|-----------------------------------|----|
| 12.1 | Introduction | 83 |
| 12.2 | Static Equivalence Translation | 83 |
| 12.3 | Kinematic Equivalence Translation | 84 |

| | |
|------------------------------------|----|
| 12.4 Stiffness Matrix Construction | 85 |
| 12.5 Conclusion | 87 |

CHAPTER THIRTEEN

MINIMUM DENOMINATOR OF RATIONAL FUNCTION

| | |
|--|----|
| 13.1 Introduction | 88 |
| 13.2 Rational Function Transformation | 88 |
| 13.3 MDRF Procedure for Non-linear Variation of the Stiffness Distribution | 89 |
| 13.4 Direct Differentiation Method | 90 |
| 13.5 Substitution Procedure | 91 |
| 13.6 Conclusion | 93 |

CHAPTER FOURTEEN

TORSIONAL STIFFNESS MATRIX OF NON-PRISMATIC BEAM ELEMENTS

| | |
|--|----|
| 14.1 Introduction | 94 |
| 14.2 Torsional - Twist Deformation Relation | 94 |
| 14.3 Deformation of the Cantilever Bar Problem | 95 |
| 14.4 Flexibility Matrix of the Cantilever Bar | 97 |
| 14.5 Stiffness Matrix | 97 |
| 14.6 Conclusion | 98 |

CHAPTER FIFTEEN

BENDING STIFFNESS MATRIX OF NON-PRISMATIC BEAM ELEMENTS

| | |
|--|-----|
| 15.1 Introduction | 99 |
| 15.2 Load - Displacement Relation | 99 |
| 15.3 Displacement of a Cantilever Bar Problem | 100 |
| 15.4 Flexibility Matrix of the Cantilever Beam | 103 |
| 15.5 Stiffness Matrix | 104 |
| 15.6 Conclusion | 104 |

CHAPTER SIXTEEN

FORMULATION OF KERNEL FUNCTION FOR AERODYNAMIC LOADING ON AIR VEHICLE

| | |
|--|-----|
| 16.1 Introduction | 105 |
| 16.2 Formulations of the Kernel Function | 105 |
| 16.3 The formulation of Watkins, Runyan and Woolston | 106 |
| 16.4 Formulations of Laschka | 107 |
| 16.5 Formulations of Yates | 109 |
| 16.6 Formulations of Landahl | 109 |
| 16.7 Conclusion | 110 |

CHAPTER SEVENTEEN

UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACE

| | |
|--------------------------------------|-----|
| 17.1 Introduction | 111 |
| 17.2 Assumptions | 111 |
| 17.3 Basic Concept | 111 |
| 17.4 Boundary Conditions | 113 |
| 17.5 Kernel Function | 113 |
| 17.6 Incomplete Cylindrical Function | 115 |
| 17.7 Conclusion | 115 |

CHAPTER EIGHTEEN

NUMERICAL EVALUATIONS OF HYPERGEOMETRIC CYLINDRICAL FUNCTIONS

| | |
|---|-----|
| 18.1 Introduction | 117 |
| 18.2 Kernel Integral Function | 117 |
| 18.3 Modified Bessel Function of the First Kind of Order 0 | 118 |
| 18.4 Modified Bessel Function of the First Kind of Order 1 | 119 |
| 18.5 Modified Bessel Function of the Second Kind of Order 0 | 120 |
| 18.6 Modified Bessel Function of the Second Kind of Order 1 | 121 |
| 18.7 Modified Struve Function | 121 |
| 18.8 Conclusion | 122 |

CHAPTER NINETEEN

ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: REAL PARTS

| | |
|---|-----|
| 19.1 Introduction | 123 |
| 19.2 The finite subinterval of the integral | 123 |
| 19.3 The Infinite Subinterval of the Integral | 125 |
| 19.4 Conclusion | 129 |

CHAPTER TWENTY

ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: IMAGINARY PARTS

| | |
|---|-----|
| 20.1 Introduction | 130 |
| 20.2 The finite subinterval of the integral | 130 |
| 20.3 The Infinite Subinterval of the Integral | 132 |
| 20.4 Conclusion | 134 |

CHAPTER TWENTY ONE

ALTERNATE EXPANSION SERIES FOR THE INCOMPLETE CYLINDRICAL FUNCTION

| | |
|---|-----|
| 21.1 Introduction | 135 |
| 21.2 Separation of Real and Imaginary Functions | 135 |
| 21.3 Separation of Regular and Singular Functions | 138 |
| 21.4 Conclusion | 139 |

CHAPTER TWENTY TWO

EXPANSION SERIES OF CONTINUOUS FUNCTION USING ANALYTICAL INTEGRATION OF LEAST SQUARE REGRESSION

| | |
|-------------------|-----|
| 22.1 Introduction | 140 |
|-------------------|-----|

| | |
|---|-----|
| 22.2 Taylor and Maclaurin expansion series | 140 |
| 22.3 Present Least Square Expansion Series | 141 |
| 22.4 Application of the Present Approach to the Incomplete Cylindrical Function | 143 |
| 22.4 Conclusion | 145 |

CHAPTER TWENTY THREE

ALTERNATE APPROXIMATE FUNCTION FOR KERNEL FUNCTION OF PLANAR OSCILLATING LIFTING SURFACES

| | |
|---|-----|
| 23.1 Introduction | 146 |
| 23.2 Epstein's Approach | 146 |
| 23.3 Present Approach for Near Field Region | 147 |
| 23.4 Present Approach for Middle Field Region | 150 |
| 23.5 Present Approach for Far Field Region | 151 |
| 23.6 Conclusion | 151 |

CHAPTER TWENTY FOUR

APPROXIMATE FUNCTION FOR NEAR-FIELD KERNEL FUNCTION OF NON-PLANAR LIFTING SURFACES

| | |
|-----------------------------------|-----|
| 24.1 Introduction | 152 |
| 24.2 Kernel Function Equation | 152 |
| 24.3 Present Approximate Function | 154 |
| 24.4 Conclusion | 157 |

CHAPTER TWENTY FIVE

APPROXIMATE FUNCTION FOR FAR-FIELD KERNEL FUNCTION OF OSCILLATING NON-PLANAR LIFTING SURFACES

| | |
|--|-----|
| 25.1 Introduction | 158 |
| 25.2 Landahl's Kernel Function Equation | 158 |
| 25.3 Present Kernel Function Formulation | 159 |
| 25.4 Conclusion | 161 |

CHAPTER TWENTY SIX

IMPROVED VORTEX LATTICE METHOD

| | |
|------------------------------------|-----|
| 26.1 Introduction | 162 |
| 26.2 Present Vortex Lattice Method | 162 |
| 26.3 Conclusion | 167 |

CHAPTER TWENTY SEVEN

IMPROVED DOUBLET POINT METHOD

| | |
|--|-----|
| 27.1 Introduction | 168 |
| 27.2 Present DPM for Planar Lifting Surfaces | 168 |
| 27.3 Present DPM for Non-Planar Lifting Surfaces | 170 |
| 27.4 Conclusion | 174 |

CHAPTER TWENTY EIGHT

IMPROVED DOUBLET LATTICE METHOD

| | |
|--|-----|
| 28.1 Introduction | 176 |
| 28.2 Present DLM for Planar Lifting Surfaces | 176 |
| 28.3 Conclusion | 179 |

CHAPTER TWENTY NINE

APPLICATION OF THE AERODYNAMIC DISCRETE ELEMENT METHODS

| | |
|---------------------------------------|-----|
| 29.1 Introduction | 180 |
| 29.2 Delta Wing with AR=2 | 180 |
| 29.3 Cropped-Double-Delta Wing | 182 |
| 29.4 Sweptback Wing with Partial Flap | 183 |
| 29.5 AGARD Wing-Horizontal Tail | 184 |
| 29.6 Conclusion | 186 |

CHAPTER THIRTY

AEROELASTIC STABILITY PROBLEM OF AIR VEHICLE

| | |
|-------------------|-----|
| 30.1 Introduction | 187 |
|-------------------|-----|

| | |
|--|-----|
| 30.2 The Flutter Solution Method | 187 |
| 30.3 Validation of the present flutter procedure | 191 |
| 30.4 Conclusion | 193 |
| <i>REFERENCES OF PART III</i> | 195 |

*BENDING STIFFNESS MATRIX OF
NON-PRISMATIC BEAM ELEMENTS*

15.1. Introduction

This chapter describes the procedure to develop the flexural stiffness matrix of beam element having arbitrary variation of bending stiffness distribution along its span. To obtain analytical formulation, the stiffness matrix is constructed from the flexibility matrix. A Bernoulli-Euler differential equation that relates the load and deformation angle derived first. The general rational function resulting from the integration of the Bernoulli-Euler is transform to a simpler rational function using the DMRF procedure given in Chapter 21. The translation axis procedure given in Chapter 20 is used to efficiently construct the stiffness matrix.

15.2. Load - Displacement Relation

Stiffness matrix formulation for a beam bending problem is more involved than the formulation for axial and torsional problems. Consider a tapered beam element of length L made of an isotropic elastic material of modulus E as shown in Fig. 23.1. Similar to the assumption adopted by Gallagher and Lee in [15], shear deflections and rotatory inertia effects are neglected for the present model. In the present section, we assume that the cross-coupling moment of inertia $I_{yz} = 0$. The treatment for $I_{yz} \neq 0$ is presented in [35]. The moment of inertia $I = I(x)$ about the z axis varies as an arbitrary polynomial function in x as follow:

$$I(x) = I_c \prod_{j=1}^N (x - c_j)^{m_j} \quad (15.1)$$