

# Contents

---

<i>Preface</i> .....	(vii)
<i>Acknowledgements</i> .....	(ix)

## Chapter 1

<b>Introduction</b>	<b>1-12</b>
1.1 Forces .....	2
1.1.1 Classification of Forces .....	3
1.1.2 Components of Forces .....	3
1.2 Units .....	4
1.2.1 Some Derived Units .....	4
1.2.2 Metric System of Units .....	5
1.3 Engineering Materials .....	5
1.3.1 Material Types .....	6
1.4 Linear Analysis .....	6
1.5 A Brief Review of Mathematics .....	7
1.5.1 Overview of Trigonometry .....	7
1.5.2 Differential & Integral Calculus .....	9
1.6 Precautions / Useful Tips to Students .....	10

## Chapter 2

<b>Coplanar Concurrent Forces</b>	<b>13-44</b>
2.1 Resolving a Force into its Components .....	13
2.1.1 Representing a Force by Vector Notation .....	15
2.2 Resultant of Two Forces Acting on a Body .....	16
2.3 Resultant of many Concurrent Forces Acting on a Body .....	19
2.4 Equilibrium of Bodies .....	21
2.4.1 Free Body Diagram (FBD) .....	22

2.4.2	Equilibrant.....	22
2.4.3	Lami's Theorem.....	23
2.4.4	Condition for Equilibrium.....	24
2.5	Normal Reaction.....	32
	<b>Summary.....</b>	<b>40</b>
	<b>Problems for Practice.....</b>	<b>41</b>

### Chapter 3

#### **Coplanar Non-concurrent Forces 45-74**

3.1	Moment of a Force .....	45
3.1.1	Sign Convention.....	46
3.1.2	Couple.....	46
3.1.3	Varignon's theorem (or Law of Moments).....	47
3.1.4	Some practical examples of moments.....	47
3.1.5	Important Rule .....	49
3.2	Resultant of Non-Concurrent Forces.....	65
3.2.1	System of Parallel Forces.....	65
3.2.2	Analytical Method.....	65
	<b>Summary.....</b>	<b>69</b>
	<b>Problems for Practice.....</b>	<b>70</b>

### Chapter 4

#### **Spatial Concurrent Forces and Vector Method 75-104**

4.1	Resolution of a Force in 3-D Space.....	76
4.2	Vector Mechanics.....	77
4.2.1	Vector Algebra.....	77
4.2.2	Moment of a Force.....	79
	<b>Summary.....</b>	<b>101</b>
	<b>Problems for Practice.....</b>	<b>102</b>

### Chapter 5

#### **Friction 105-150**

5.1	Frictional Resistance .....	105
5.2	Laws of Friction .....	106

5.3 Cone of Friction.....	107
5.4 Angle of Repose ‘ $\theta$ ’ .....	107
5.5 Inclined Plane .....	107
5.6 Power Screw or Screw Jack.....	125
5.6.1 Law of Machine .....	126
5.6.2 Self-locking Screw .....	127
5.6.3 Non Self-locking Screw .....	128
5.6.4 Differential Screw Jack.....	128
5.7 Belt Drives.....	130
5.7.1 Types of Belt Drives .....	130
5.7.2 Arrangements of Flat Belt Drives .....	131
5.7.3 Special Features of Belt Drives.....	136
<b><i>Summary</i></b> .....	<b>141</b>
<b><i>Problems for Practice</i></b> .....	<b>146</b>

## Chapter 6

### Centroid151-178

6.1 Centroid, Center of Mass & Center of Gravity.....	151
6.1.1 Centroids of Composite Bodies .....	152
6.2 Centroid of Circular Arcs .....	152
6.3 Centroid of Plane Areas (Assuming Uniform Thickness and Density).....	158
6.3.1 Centroid of a Sector of a Circular Plate .....	158
6.3.2 Centroid of other Plane Areas .....	159
6.4 Centroids of Solids of Revolution .....	168
6.5 Centroids of Composite Solids of Revolution.....	170
6.5.1 Pappu’s Theorem.....	171
6.5.2 Guldinus Theorem (Also called Pappus Theorem-2).....	172
<b><i>Summary</i></b> .....	<b>173</b>
<b><i>Some Useful Results</i></b> .....	<b>175</b>
<b><i>Problems for Practice</i></b> .....	<b>176</b>

## Chapter 7

### Area Moment of Inertia 179-208

7.1 Moment of Inertia of Some Simple Shapes.....	180
7.1.1 Rectangular Section .....	183
7.1.2 Triangular Section.....	185
7.1.3 Circular Section of Radius ‘R’ .....	185
7.1.4 Thin Circular Ring of Mean Radius ‘R’ and Thickness ‘t’ .....	186
7.1.5 Ellipse of Semi-major Axis ‘a’ and Semi-minor Axis ‘b’ .....	187
7.2 Parallel Axes Theorem .....	187
7.3 Moment of Inertia of Composite Sections.....	189
7.3.1 Hollow Rectangular Section .....	189
7.3.2 Hollow Circular Section.....	190
7.3.3 T-section.....	190
7.3.4 I-section.....	191
7.3.5 L – section.....	192
7.3.6 C – section.....	193
7.4 Product of Inertia.....	195
7.5 Rotation of Axes.....	196
7.6 Mohr’s Circle of Inertia.....	197
7.7 Radius of Gyration .....	201
<b>Summary.....</b>	<b>205</b>
<b>Some Useful Values .....</b>	<b>207</b>
<b>Problems for Practice.....</b>	<b>208</b>

## Chapter 8

### Mass Moment of Inertia 209-224

8.1 Parallel Axes Theorem .....	210
8.2 Mass Moment of Inertia of Three-Dimensional Bodies .....	213
8.3 Moment of Inertia of Composite Sections.....	218
8.4 Product of Inertia.....	222
8.5 Radius of Gyration .....	222
<b>Summary.....</b>	<b>223</b>
<b>Some Useful Results .....</b>	<b>223</b>

## **Chapter 9**

<b>Trusses</b>	<b>225-240</b>
9.1 Frame .....	225
9.2 Truss .....	225
9.2.1 Types of Trusses .....	226
9.3 Analysis of Plane Trusses.....	228
9.3.1 Analysis by Method of Joints.....	229
9.3.2 Analysis by Method of Sections .....	236
<i>Summary</i> .....	<b>239</b>

## **Chapter 10**

<b>Beams and Mechanics</b>	<b>241-264</b>
10.1 Beam .....	241
10.2 Shear Force and Bending Moment .....	242
10.2.1 Relationship between Shear Force and Bending Moment .....	244
10.2.2 Points of Contra-flexure .....	245
10.3 Deflection of a Simple Beam.....	248
10.3.1 Euler-Bernoulli Beam Theory .....	249
10.3.2 Neutral Plane & Neutral Axis .....	250
10.3.3 Deflection by Double Integration Method .....	250
10.3.4 Macaulay's Notation .....	250
10.4 Bending Stress .....	254
10.4.1 Theory of Bending .....	254
10.4.2 Bending Stress Distribution .....	255
10.4.3 Combined Bending and Axial Loads .....	256
10.4.4 Shear Stress in a Beam .....	256
10.4.5 Shear Stress Distribution.....	259
10.5 Mechanisms.....	260
10.5.1 Four-bar or Quadric Cycle Chain (R-R-R-R Type Mechanism).....	260
10.5.2 Single Slider Crank Chain.....	261

10.5.3	Beam Engine or Crank and Lever Mechanism .....	261
10.5.4	Crank and Slotted Lever (Quick Return Motion Mechanism) .....	262
10.5.5	Scotch yoke Mechanism .....	262
10.5.6	Oldham Coupling .....	263

## Chapter 11

<b>Kinematics</b>		<b>265-300</b>
11.1	Motion of a Rigid Body .....	265
11.2	Rectilinear Motion .....	265
11.2.1	Rectilinear Motion with Constant Acceleration .....	266
11.2.2	Graphical Representation of Velocity and Distance Travelled ...	271
11.2.3	Relative Velocity .....	273
11.2.4	Rectilinear Motion with variable Acceleration .....	276
11.3	Curvilinear Motion .....	279
11.3.1	Path of a Projectile .....	282
11.3.2	Projectile on an Inclined Plane .....	288
11.4	Rotation of Rigid Bodies .....	292
	<b>Summary</b> .....	<b>296</b>
	<b>Problems for Practice</b> .....	<b>298</b>

## Chapter 12

<b>Kinetics</b>		<b>301-324</b>
12.1	D’alembert Principle .....	301
12.1.1	Velocity, Acceleration and Distance as a Function of External Force .....	302
12.2	Centrifugal Force .....	312
12.2.1	Motion of an Automobile on Level Ground .....	312
12.2.2	Banking (slope) of Road .....	313
12.3	Fixed Axis Rotation .....	315
12.4	Rolling Bodies .....	317

12.5 Momentum of Bodies in Collision .....	319
12.5.1 Law of Conservation of Momentum .....	319
12.5.2 Coefficient of Restitution (e) .....	319
<b>Summary</b> .....	<b>322</b>

## **Chapter 13**

<b>Vibrations</b>	<b>325-336</b>
13.1 Classification of Vibrations .....	325
13.2 Simple Harmonic Motion .....	326
13.3 Simple Pendulum.....	329
13.4 Compound Pendulum .....	331
13.5 Springs Connected in Series and Parallel .....	333
<b>Problems for Practice</b> .....	<b>334</b>

## **Chapter 14**

<b>Work - Energy</b>	<b>337-349</b>
14.1 Energy.....	337
14.2 Work Done by a Moving Body .....	337
14.3 Relation between Energy and Work .....	338
14.4 Work and Energy in Fixed Axis Rotation .....	342
14.5 Work and Energy in Plane Motion .....	344