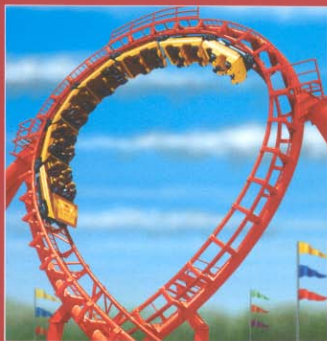


INTERNATIONAL EDITION

ENGINEERING MECHANICS

DYNAMICS

TENTH EDITION



R. C. Hibbeler

Dynamics



12

Kinematics of a Particle 3

Chapter Objectives 3

- 12.1 Introduction 3
- 12.2 Rectilinear Kinematics: Continuous Motion 5
- 12.3 Rectilinear Kinematics: Erratic Motion 18
- 12.4 General Curvilinear Motion 31
- 12.5 Curvilinear Motion: Rectangular Components 33
- 12.6 Motion of a Projectile 38
- 12.7 Curvilinear Motion: Normal and Tangential Components 49
- 12.8 Curvilinear Motion: Cylindrical Components 62
- 12.9 Absolute Dependent Motion Analysis of Two Particles 77
- 12.10 Relative-Motion Analysis of Two Particles Using Translating Axes 83



13

Kinetics of a Particle: Force and Acceleration 97

Chapter Objectives 97

- 13.1 Newton's Laws of Motion 97
- 13.2 The Equation of Motion 101
- 13.3 Equation of Motion for a System of Particles 104
- 13.4 Equations of Motion: Rectangular Coordinates 106

- 13.5 Equations of Motion: Normal and Tangential Coordinates 123
- 13.6 Equations of Motion: Cylindrical Coordinates 135
- ★13.7 Central-Force Motion and Space Mechanics 146



14

Kinetics of a Particle: Work and Energy 159

Chapter Objectives 159

- 14.1 The Work of a Force 159
- 14.2 Principle of Work and Energy 164
- 14.3 Principle of Work and Energy for a System of Particles 166
- 14.4 Power and Efficiency 182
- 14.5 Conservative Forces and Potential Energy 190
- 14.6 Conservation of Energy 194



15

Kinetics of a Particle: Impulse and Momentum 207

Chapter Objectives 207

- 15.1 Principle of Linear Impulse and Momentum 207
- 15.2 Principle of Linear Impulse and Momentum for a System of Particles 214

- 15.3 Conservation of Linear Momentum for a System of Particles 222
- 15.4 Impact 233
- 15.5 Angular Momentum 246
- 15.6 Relation Between Moment of a Force and Angular Momentum 247
- 15.7 Angular Impulse and Momentum Principles 250
- ★15.8 Steady Fluid Streams 260
- ★15.9 Propulsion with Variable Mass 265

Review 1: Kinematics and Kinetics of a Particle 278



16

Planar Kinematics of a Rigid Body 293

- Chapter Objectives 293
- 16.1 Rigid-Body Motion 293
- 16.2 Translation 295
- 16.3 Rotation About a Fixed Axis 296
- 16.4 Absolute General Plane Motion Analysis 309
- 16.5 Relative-Motion Analysis: Velocity 319
- 16.6 Instantaneous Center of Zero Velocity 333
- 16.7 Relative-Motion Analysis: Acceleration 343
- 16.8 Relative-Motion Analysis Using Rotating Axes 358



17

Planar Kinetics of a Rigid Body: Force and Acceleration 377

- Chapter Objectives 377
- 17.1 Moment of Inertia 377

- 17.2 Planar Kinetic Equations of Motion 391
- 17.3 Equations of Motion: Translation 394
- 17.4 Equations of Motion: Rotation About a Fixed Axis 406
- 17.5 Equations of Motion: General Plane Motion 422



18

Planar Kinetics of a Rigid Body: Work and Energy 437

- Chapter Objectives 437
- 18.1 Kinetic Energy 437
- 18.2 The Work of a Force 441
- 18.3 The Work of a Couple 443
- 18.4 Principle of Work and Energy 445
- 18.5 Conservation of Energy 459



19

Planar Kinetics of a Rigid Body: Impulse and Momentum 471

- Chapter Objectives 471
- 19.1 Linear and Angular Momentum 471
- 19.2 Principle of Impulse and Momentum 477
- 19.3 Conservation of Momentum 492
- 19.4 Eccentric Impact 496

Review 2: Planar Kinematics and Kinetics of a Rigid Body 506



20

Three-Dimensional Kinematics of a Rigid Body 523

- Chapter Objectives 523
- 20.1 Rotation About a Fixed Point 523
- *20.2 The Time Derivative of a Vector
Measured from Either a Fixed and
Translating-Rotating System 526
- 20.3 General Motion 531
- *20.4 Relative-Motion Analysis Using
Translating and Rotating Axes 540



21

Three-Dimensional Kinetics of a Rigid Body 553

- Chapter Objectives 553
- *21.1 Moments and Products of Inertia 553
- *21.2 Angular Momentum 563
- *21.3 Kinetic Energy 566
- *21.4 Equations of Motion 574
- *21.5 Gyroscopic Motion 588
- *21.6 Torque-Free Motion 594



22

Vibrations 605

- Chapter Objectives 605
- *21.1 Undamped Free Vibration 605
- *21.2 Energy Methods 618
- *21.3 Undamped Forced Vibration 624
- *21.4 Viscous Damped Free Vibration 628
- *21.5 Viscous Damped Forced Vibration 632
- *21.6 Electrical Circuit Analogs 634

Appendices

- A. Mathematical Expressions 640
- B. Numerical and Computer Analysis 642
- C. Vector Analysis 651
- D. Review for the Fundamentals
of Engineering Examination 655

Answers to Selected Problems 671

Index 681