

CONTENTS

Chapter 1. Introduction	1
Purpose	1
Historical Perspective	2
Text Outline	8
References	12
Chapter 2. Materials, Processing, and Design	13
Plastic Materials	14
Crystalline and Amorphous Polymers	15
Polymer Blends and Alloys	17
Reinforcements, Fillers , and Additives	18
Engineering Data and Materials Selection	20
Processing Considerations	22
Design Engineering	25
Closure	30
References	30
Chapter 3. Finite-Element Analysis Techniques and Nonlinear Issues	31
Structural Finite-Element Analysis: Theoretical Basis	33
Fundamentals	35
Displacement Function	36
Element Displacements in Terms of Nodal Displacements	37
Strains as a Function of Nodal Displacements	37
Stresses in Terms of Strains	38
Nodal Forces in Terms of Displacements	38
Global Equilibrium	39
Types of Finite Elements	40
One-Dimensional Elements	40
Two-Dimensional Elements	41
Three-Dimensional Elements	44
Beam, Plate, and Shell Elements	44
Finite-Element Analysis Procedure	45
Geometry Creation	45
Mesh Creation and Element Selection	46
Boundary and Loading Conditions	47
Material Properties	47
Interpretation of Results	48

Nonlinear Issues in Results	48
Nonlinearity Due to Material Behavior	49
Nonlinearity Due to Large Displacements in Thin Plastic Components	51
Nonlinearity Due to Large Rotations in Beams and Plates	52
Nonlinearity Due to the Load-Deformation Interaction	64
Closure	67
References	68
Chapter 4. Stiffness	69
Issues of Material Stiffness	76
Part Stiffness Prediction from Standard Stress-Strain Measurements	77
Characterizing Materials Stiffness of Thermoplastic Structural Foam	83
Material Issues for Long-Glass-Fiber Compression-Molded Thermoplastic Sheets	106
Structural Stiffness Concepts for Plastic Parts	122
Stiff Plastic Beams	122
Stiff Plastic Plates	129
Stiff Blow-Molded Panels	132
Closure	146
References	147
Chapter 5. Failure	151
Strength of Short-Fiber-Reinforced Thermoplastics	154
Failure Use to Yielding and Plasticity	161
Observed Tensile Test Behavior in Ductile Thermoplastics	163
Initial Yield and Maximum Load	169
Strain Localization, Necking, and Neck Propagation	176
Neck Propagation and Rupture in the Puncture Test	185
Notch Sensitivity and Crazeing	196
Temperature Effects upon Failure Mode	207
Fracture Mechanics	213
Instability and Collapse of Thin Plastic Components under Compression	227
Other Engineering Considerations Pertinent to Strength and Failure	232
Closure	233
References	236
Chapter 6. Designing for Impact with Plastic Materials	241
Definition of Impact Events	242
Impact Response: Transient Dynamic Effects	244
Damping Effects	249
Continuous Systems and Wave Propagation	249
Load Definition in Impact Events	255

Impact Response: Material Consideration	268
Rate Effects upon Yield Stress	270
Rate Effects and Material Behavior in the Large-Strain Range	279
Effect of Strain Rate and Temperature on Failure Mode	285
Closure	294
Chapter 7. Time-Dependent Part Performance	297
Creep and Stress Relaxation	298
Viscoelastic Models	299
Measurement of Time-Dependent Deformation	302
Creep Models: Interpretation of Data	303
Mathematical Creep Model	304
Graphical Curve-Fitting Technique	307
Time-Dependent Design Analysis	311
Variable Loading and Recovery	319
Time-Dependent Rupture	322
References	327
Chapter 8. Fatigue: Cycle-Dependent Part Performance	329
General Load-Lifetime (S-N) Fatigue Representation	330
Control Mode-Load or Deflection	332
Frequency Effects and Hysterectic Heating	333
Cyclic Waveform	337
Relationships between Creep Rupture and Fatigue	337
Stress Concentrations	338
Mean Stress	344
Fatigue State	345
Component Lifetime Prediction	347
References	349
Chapter 9. Closure	351
Glossary	359
Index	361