Table of Contents

1	**Stress and Strain**	
1.1	Free Energy and Stress	1
1.2	Interrelationship Among the Stresses in Elastic Body	4
1.3	Viscoelasticity	8
1.3.1	Stress Relaxation	8
1.3.2	Superposition of the Stress-strain History	11
1.4	The Relaxation Spectrum	15
1.4.1	Phenomenological Aspects	15
1.4.2	The Three Stages of Relaxation	18
1.4.3	Molecular Interpretation	23
1.4.3.1	Conformational Relaxation Without Cooperativity	23
1.4.3.2	Cooperativity in Stage 1 Relaxation	30
1.4.3.3	External Viscosity: Stage 2 and 3	31
1.5	Approximate Relations Among Linear Viscoelastic Functions	31
1.6	The Yield Phenomenon	34
2	**Intermolecular Cooperativity**	
2.1	A Molecular Model for Intermolecular Cooperativity	42
2.2	Distribution of Relaxation Times near the Glass Transition	65
2.2.1	Stage 1: Relaxation of Conformers	65
2.2.2	Stage 2: The "Transition" Zone	74
3	**The Glassy State**	
3.1	Isothermal Contraction/Expansion in the Nonequilibrium State	80
3.2	Linear Viscoelastic Relaxation in the Glassy State	100
3.3	Plasticity and Nonlinear Viscoelasticity in the Glassy State	111
3.3.1	The Magnitude of Relaxation Time in Glassy Polymers	111
3.3.2	The Free Volume Hypothesis	113
3.3.3	Plasticity and Yield Phenomena	119
3.3.4	Viscoplasticity and Nonlinear Viscoelasticity	126
3.3.5	Engineering Scaling Rules for Creep, Relaxation, and Stress-Strain	132
3.3.6	Invariants in Elasticity	136
3.3.7	The Hypothesis of Domain Breakup During Yield	141

4	**The Molten State**	
4.1	Elements of Melt Rheology	143
4.2	Rubber Elasticity	148
4.3	Linear Viscoelasticity without Entanglement: Stage 2	159
4.4	Linear Viscoelasticity with Entanglement: Stage 3	168
4.5	The Melt Flow	178
4.6	Additional Comments	190
4.6.1	The Vertical Shift Factor and the BKZ Theory	190
4.6.2	The Stress Overshoot	193
4.6.3	Normal Stresses	195
5	**The Crystalline State**	
5.1	Melting and Crystallization	198
5.2	Relaxation of Semicrystalline Polymers as Composite Structures	211
5.3	Engineering Properties	225
6	**Related Topics**	
6.1	The Glass Transition in Crosslinked Polymers (Thermosets)	237
6.2	Failure in Plastics	250
6.2.1	Polymers Above T_g	250
6.2.2	Polymer Solids	256
6.2.3	Crazing and Stress Cracking	257
6.2.4	Impact Strength and the Brittle-Ductile Transition Temperature	258
6.3	Polymer Solutions	264
7	**Computer Programs in BASIC**	
7.1	Engineering Properties of Glassy and Crystalline Polymers	275
7.1.1	Nomenclature for POLYMER1.BAS	277
7.1.2	Nomenclature in the Program	278
7.1.3	Optional Subroutines	280
7.1.4	Function Keys	280
7.2	The Program	281
7.3	Thermodynamic Recovery	301
	Nomenclature	313
	Index	317