

CONTENTS

<i>Dedication</i>	page	vi
<i>Preface</i>		xi
<i>Acknowledgments</i>		xvii
1 THERMODYNAMIC CONSIDERATIONS		<i>1</i>
1.1 The Ideal Otto Cycle		1
1.2 Efficiencies		5
1.2.1 Air Cycle Efficiency		5
1.2.2 Real Gas Efficiency		6
1.2.3 Indicated Efficiency		6
1.3 A More Realistic Cycle		7
1.3.1 Time Loss		8
1.3.2 Heat Loss		9
1.3.3 Exhaust Blowdown Loss		9
1.3.4 Other Losses		9
1.4 Knocking		12
1.5 Mean Effective Pressures		15
1.5.1 A Word on Units		15
1.5.2 Brake Mean Effective Pressure		16
1.5.3 Indicated Mean Effective Pressure		17
1.6 Piston Speed		17
1.7 Specific Power		18
1.8 Stroke/Bore Ratio		19
1.9 Power Equation		24
1.10 Influence on Design		26
1.11 Bmep Again		27
1.12 Some More Thermodynamics		29
1.12.1 Turbulence and Flow in the Cylinder		29
1.12.2 Heat Transfer		30
1.12.3 Chemical Reaction		30
1.12.4 STANJAN, ESPJAN and ESP		31
1.12.5 Heating Values and Enthalpy		31
1.13 Problems		31

2	BREATHING EXERCISES	33
2.1	Introduction	33
2.2	Flow Through the Inlet Valve	33
2.3	The Discharge Coefficient	35
2.4	The Flow Coefficient	37
2.5	The Mach Index and Volumetric Efficiency	38
2.6	Partial Throttle	41
2.7	The XK Engine	42
2.8	Combustion Chamber Shape	44
2.9	Valve Actuation	48
2.10	Valve Timing	54
2.11	Variable Valve Timing	59
2.12	Manifold Tuning	66
2.12.1	Introduction	66
2.12.2	Helmholtz Resonators	66
2.12.3	Organ Pipes	70
2.12.4	What Does ESP Do?	76
2.12.5	The Exhaust System	77
2.13	Folding the Manifold	78
2.14	Supercharging/Turbocharging	80
2.14.1	Introduction	80
2.14.2	Characteristics of Super/Turbochargers	82
2.14.3	Thermodynamic Considerations	85
2.14.4	Turbines	87
2.14.5	Knock	87
2.15	Intercoolers	89
2.16	Problems	92
3	ENGINE COOLING	95
3.1	Introduction	95
3.2	Valve Seat Recession	97
3.3	Heat Transfer in the Cylinder	100
3.3.1	Conduction in the Solid	100
3.3.2	Heat Transfer in the Gas	101
3.3.3	Variation of Part Temperature	103
3.3.4	Turbulent Velocities	104
3.3.5	Conclusions Regarding Temperatures	106
3.4	Overall Heat Transfer	106
3.5	The Exhaust Valve	111
3.6	Ceramic Coatings	114
3.7	Problems	116
4	ENGINE FRICTION LOSSES	118
4.1	Lubrication	118
4.2	Total Engine Friction	119

4.3	Attribution of Friction Losses	122
4.4	Hydrodynamic Lubrication	125
4.5	Mechanical Efficiency	127
4.6	Inertial Loading	129
4.7	The Piston Ring	130
4.8	Problems	132
5	FLOW IN THE CYLINDER	134
5.1	Introduction	134
5.2	Phases of the Flow	136
5.3	Averaging	137
5.4	A Word About Turbulence	142
5.5	Turbulence Induced by the Inlet Jet	145
5.6	Inducing Swirl and Tumble	148
5.6.1	Lift Strategies	153
5.6.2	Port and Valve Configurations	153
5.7	Effect of Compression	155
5.7.1	Effect on Swirl and Tumble	155
5.7.2	Effect on Turbulence	158
5.8	Charge Stratification	161
5.9	Squish	163
5.10	Pollution	163
5.10.1	Atmospheric Chemistry	168
5.10.2	Chemistry in the Cylinder	168
5.11	Lean Burn	170
5.11.1	Honda VTEC-E 1.5 L SOHC16Valve Four-in-Line	172
5.11.2	Toyota Carina 4A-ELU 1.6 L DOHC 16 Valve Four-in-Line	172
5.11.3	Mitsubishi Mirage 4G15MPI-MVV 1.5 L SOHC 12 Valve Four-in-Line	172
5.11.4	Mazda Surround Combustion 2.0 L DOHC 16 Valve Four-in-Line	173
5.12	Gasoline Direct-Injection Engines	174
5.12.1	Mitsubishi GDI Engine	181
5.12.2	Toyota GDI Engine	181
5.13	Problems	181
6	OVERALL ENGINE PERFORMANCE	185
6.1	Introduction	185
6.2	Carburetion vs. Injection	185
6.2.1	Fuel Injection	186
6.2.2	Mixing and Evaporation	186
6.2.3	Droplet Size	187
6.2.4	Puddling	188

6.3	Transient Response	189
6.4	Brake Specific Fuel Consumption	189
6.4.1	Power and Torque Curves	191
6.5	Problems	193
7	DESIGN CONSIDERATIONS	194
7.1	Introduction	194
7.2	Similarity Considerations	194
7.2.1	Inertial Stress	196
7.2.2	Valve Speed	197
7.2.3	The MIT Engines	199
7.3	Balance and Vibration	201
7.4	The In-Line Four	203
7.4.1	The Forces	203
7.4.2	Moments	204
7.4.3	Balance Shafts	205
7.5	The Five Cylinder In-Line	205
7.6	Problems	208
8	THE STANFORD ESP	210
8.1	Introduction	210
8.2	Outline of the Model	211
8.3	Model Details	213
8.3.1	Gas Properties	213
8.3.2	Analysis of the Compression Stages	213
8.3.3	Ignition Analysis	214
8.3.4	Analysis of the Burn Stage	215
8.3.5	Analysis of the Expansion Stage	218
8.3.6	Analysis of the Gas Exchange Stage	218
8.3.7	Turbulence Model	221
8.4	ESP Manifold Analysis	222
8.4.1	Overview	222
8.4.2	Unsteady One-Dimensional Compressible Flow	223
8.4.3	The Method of Characteristics	226
8.4.4	Inlet Manifold Model	232
8.4.5	Exhaust Manifold Model	233
8.4.6	ESP Calculations	234
8.5	Program Status	235
	<i>Bibliography</i>	237
	<i>Index</i>	243