## Contents

Acknowledgements				
Preface				
Ab	out th	e author	xii	
1	Vehicle refinement: purpose and targets			
	1.1	Introduction and definitions	1	
	1.2	Scope of this book	2	
	1.3	The purpose of vehicle refinement	3	
	1.4	How refinement can be achieved in the automotive industry	5	
	1.5	The history of vehicle refinement: one representative 20-year example	6	
	1.6	Refinement targets	9	
	Refe	rences	15	
2	The measurement and behaviour of sound			
	2.1	How sound is created and how it propagates	17	
	2.2	Making basic noise measurements: the sound level meter, recording		
		sound	33	
	2.3	Making basic noise measurements: the decibel scale, frequency and		
		time weightings	43	
	2.4	Analysis and presentation of noise data	48	
	2.5	Sound power level, sound intensity level, sound pressure level	59	
	References		70	
	Appe	endix 2A: Introduction to logarithms	72	
3	Exterior noise: assessment and control			
	3.1	Pass-by noise homologation	74	
	3.2	Noise source ranking	81	
	3.3	Air intake systems and exhaust systems: performance and		
		noise effects	84	
	3.4	Tyre noise	136	
	References			
	Appendix 3A: Valve and port geometry		144	

viii	Contents
------	----------

4	Inter	ior noise: assessment and control	145
	4.1	Subjective and objective methods of assessment	145
	4.2	Noise path analysis	151
	4.3	Measuring the sound power of IC engines and other vehicle noise	
		sources	159
	4.4	Engine noise	173
	4.5	Road noise	179
	4.6	A note on aerodynamic (wind) noise	181
	4.7	A note on brake noise	182
	4.8	A note on squeak, rattle and tizz noises	183
	4.9	Control of sound through absorption within porous materials	184
	4.10	Control of sound by minimising transmission through panels	194
	Refe	rences	211
	Appendix 4A: Some background information on systems		
	Appendix 4B: The convolution integral		217
	Appendix 4C: The covariance function, correlation and coherence		220
	Appendix 4D: The frequency response function		225
	Appendix 4E: Plane waves in a tube with a termination impedance		227
	Appendix 4F: The derivation of the linearised mass conservation equation		231
	Appendix 4G: The derivation of the non-linear (and linearised) inviscid		
		Euler equation	233
5	The measurement and behaviour of vibration		
5	5.1	Making basic vibration measurements	234
	5.1	Laser based vibration measurements	234
	53	Analysis and presentation of vibration data: quantifying vibration	230
	5.5	Modes of vibration and resonance	240
	5.5	Model analysis	240
	J.J Refei	rences	269
	Refer		200
6	Sources of vibration and their control		
	6.1	Introduction	269
	6.2	Damping of vibrations	269
	6.3	Vibration isolation and absorption	287
	6.4	Engine and drivetrain vibrations	299
	6.5	Vehicle and chassis vibrations: ride quality	334
	Refei	rences	338
In	dex		341
1,10	IIIICA		0.1