

# Contents

<i>Preface to the Fifth Edition</i>	ix
<i>Acknowledgments</i>	xi
<i>Acronyms</i>	xiii
<i>Nomenclature</i>	xvii
<i>About the Companion Website</i>	xix

<b>Chapter 1 Basic principles</b>	1
Introduction	1
Atomic structure	2
Motion in the atom	2
MR-active nuclei	4
The hydrogen nucleus	5
Alignment	6
Net magnetic vector (NMV)	8
Precession and precessional (Larmor) frequency	10
Precessional phase	13
Resonance	13
MR signal	18
The free induction decay (FID) signal	20
Pulse timing parameters	22

<b>Chapter 2 Image weighting and contrast</b>	24
Introduction	24
Image contrast	25
Relaxation	25
T1 recovery	26
T2 decay	27
Contrast mechanisms	31
Relaxation in different tissues	32
T1 contrast	36
T2 contrast	40
Proton density contrast	41
Weighting	42
Other contrast mechanisms	51

<b>Chapter 3</b>	<b>Spin-echo pulse sequences</b>	<b>58</b>
Introduction	58	Inversion recovery (IR) 78
RF rephasing	59	Short tau inversion recovery (STIR) 82
Conventional spin-echo	65	Fluid attenuated inversion recovery (FLAIR) 84
Fast or turbo spin-echo (FSE/TSE)	68	

<b>Chapter 4</b>	<b>Gradient-echo pulse sequences</b>	<b>89</b>
Introduction	89	Incoherent or spoiled gradient-echo 109
Variable flip angle	90	Reverse-echo gradient-echo 113
Gradient rephasing	91	Balanced gradient-echo 119
Weighting in gradient-echo pulse sequences	94	Fast gradient-echo 122
Coherent or rewound gradient-echo	106	Echo planar imaging 122

<b>Chapter 5</b>	<b>Spatial encoding</b>	<b>128</b>
Introduction	128	Frequency encoding 142
Mechanism of gradients	129	Phase encoding 145
Gradient axes	134	Bringing it all together – pulse sequence timing 152
Slice-selection	135	

<b>Chapter 6</b>	<b><i>k</i>-Space</b>	<b>158</b>
Introduction	158	Part 3: Some important facts about <i>k</i> -space! 184
Part 1: What is <i>k</i> -space?	159	
Part 2: How are data acquired and how are images created from these data?	165	Part 4: How do pulse sequences fill <i>k</i> -space? 197
		Part 5: Options that fill <i>k</i> -space 199

<b>Chapter 7</b>	<b>Protocol optimization</b>	<b>209</b>
Introduction	209	Scan time 237
Signal-to-noise ratio (SNR)	210	Trade-offs 238
Contrast-to-noise ratio (CNR)	226	Protocol development and modification 238
Spatial resolution	232	

<b>Chapter 8 Artifacts</b>	<b>242</b>
Introduction	242
Phase mismapping	243
Aliasing	253
Chemical shift artifact	261
Out-of-phase signal cancellation	265
Magnetic susceptibility artifact	269
Truncation artifact	272
Cross-excitation/cross-talk	273
Zipper artifact	275
Shading artifact	276
Moiré artifact	277
Magic angle	279
Equipment faults	280
Flow artifacts	280
Flow-dependent (non-contrast-enhanced) angiography	298
Black-blood imaging	303
Phase-contrast MRA	304

<b>Chapter 9 Instrumentation</b>	<b>311</b>
Introduction	311
Magnetism	313
Scanner configurations	315
Magnet system	318
Magnet shielding	326
Shim system	328
Gradient system	330
RF system	337
Patient transport system	343
Computer system and graphical user interface	344

<b>Chapter 10 MRI Safety</b>	<b>346</b>
Introduction (and disclaimer)	346
Definitions used in MRI safety	347
Psychological effects	350
The spatially varying static field	351
Electromagnetic (radiofrequency) fields	357
Time-varying gradient magnetic fields	363
Cryogens	365
Safety tips	367
Additional resources	368

<i>Glossary</i>	370
<i>Index</i>	387

