

Contents

1	Welcome to Python	1
1.1	Why Python?	1
1.1.1	Python is a general-purpose high-level programming language	1
1.1.2	Python integrates well with data analysis, visualisation and GUI toolkits	2
1.1.3	Python ‘plays well with others’	2
1.2	Common misconceptions about Python	2
1.3	Roadmap for this book	3
2	The PPF Package	5
2.1	PPF topology	5
2.2	Unit testing	6
2.2.1	doctest	6
2.2.2	PyUnit	7
2.3	Building and installing PPF	7
2.3.1	Prerequisites and dependencies	7
2.3.2	Building the C++ extension modules	8
2.3.3	Installing the PPF package	9
2.3.4	Testing a PPF installation	9
3	Extending Python from C++	11
3.1	Boost.Date_Time types	11
3.1.1	Examples	12
3.2	Boost.MultiArray and special functions	17
3.3	NumPy arrays	19
3.3.1	Accessing array data in C++	19
3.3.2	Examples	23
4	Basic Mathematical Tools	27
4.1	Random number generation	27
4.2	$N(\cdot)$	28
4.3	Interpolation	29
4.3.1	Linear interpolation	31

4.3.2	Loglinear interpolation	32
4.3.3	Linear on zero interpolation	32
4.3.4	Cubic spline interpolation	33
4.4	Root finding	35
4.4.1	Bisection method	35
4.4.2	Newton–Raphson method	36
4.5	Linear algebra	38
4.5.1	Matrix multiplication	38
4.5.2	Matrix inversion	38
4.5.3	Matrix pseudo-inverse	39
4.5.4	Solving linear systems	39
4.5.5	Solving tridiagonal systems	39
4.5.6	Solving upper diagonal systems	40
4.5.7	Singular value decomposition	42
4.6	Generalised linear least squares	44
4.7	Quadratic and cubic roots	46
4.8	Integration	49
4.8.1	Piecewise constant polynomial fitting	49
4.8.2	Piecewise polynomial integration	51
4.8.3	Semi-analytic conditional expectations	57
5	Market: Curves and Surfaces	63
5.1	Curves	63
5.2	Surfaces	64
5.3	Environment	65
6	Data Model	69
6.1	Observables	69
6.1.1	LIBOR	70
6.1.2	Swap rate	74
6.2	Flows	79
6.3	Adjuvants	82
6.4	Legs	84
6.5	Exercises	85
6.6	Trades	87
6.7	Trade utilities	88
7	Timeline: Events and Controller	93
7.1	Events	93
7.2	Timeline	94
7.3	Controller	97
8	The Hull–White Model	99
8.1	A component-based design	99
8.1.1	Requestor	100
8.1.2	State	101
8.1.3	Filler	104

8.1.4	Rollback	108
8.1.5	Evolve	112
8.1.6	Exercise	115
8.2	The model and model factories	118
8.3	Concluding remarks	121
9	Pricing using Numerical Methods	123
9.1	A lattice pricing framework	123
9.2	A Monte-Carlo pricing framework	128
9.2.1	Pricing non-callable trades	129
9.2.2	Pricing callable trades	131
9.3	Concluding remarks	142
10	Pricing Financial Structures in Hull–White	145
10.1	Pricing a Bermudan	145
10.2	Pricing a TARN	152
10.3	Concluding remarks	157
11	Hybrid Python/C++ Pricing Systems	159
11.1	nth_imm_of_year revisited	159
11.2	Exercising nth_imm_of_year from C++	161
12	Python Excel Integration	165
12.1	Black–scholes COM server	165
12.1.1	VBS client	167
12.1.2	VBA client	167
12.2	Numerical pricing with PPF in Excel	168
12.2.1	Common utilities	168
12.2.2	Market server	169
12.2.3	Trade server	176
12.2.4	Pricer server	187
Appendices		191
A	Python	193
A.1	Python interpreter modes	193
A.1.1	Interactive mode	193
A.1.2	Batch mode	193
A.2	Basic Python	194
A.2.1	Simple expressions	194
A.2.2	Built-in data types	195
A.2.3	Control flow statements	197
A.2.4	Functions	200
A.2.5	Classes	201
A.2.6	Modules and packages	203
A.3	Conclusion	205

B Boost.Python	207
B.1 Hello world	207
B.2 Classes, constructors and methods	207
B.3 Inheritance	209
B.4 Python operators	212
B.5 Functions	212
B.6 Enums	214
B.7 Embedding	214
B.8 Conclusion	216
C Hull–White Model Mathematics	217
D Pickup Value Regression	219
Bibliography	221
Index	223