

Contents

Acknowledgements	i
Notations	ix
Abbreviations	xi
List of Tables	xiv
List of Figures	xvii
Abstract	xviii
1 Introduction	1
1.1 Fractional Calculus	1
1.2 Fractional Differential equations	3
1.2.0 Why Fractional Differential Equation?	4
1.2.1 Analytical and Numerical methods	5
1.2.2 Integral transform	5
1.2.3 Semi-Analytical methods	6
1.3 Mathematical Modeling	7
1.3.1 Epidemic Models	7
1.4 Contribution towards knowledge extension	8
1.5 Preliminaries	11
2 Fractional Korteweg-de Vries and Kawahara equations	13
2.1 Introduction	13
2.2 Preliminaries	15
2.3 Analysis of Fractional Residual Power Series Method	16
2.3.1 Convergence Analysis of FRPSM	18

2.4	Application of the FRPSM and Numerical Discussions	19
2.4.1	Solution of Fractional KdV Equation	19
2.4.2	Solution of fractional Kawahara type - 1 equation	25
2.4.3	Solution of fractional Kawahara type - 2 equation	31
2.4.4	Solution of fractional Modified Kawahara type-1 equation	34
2.4.5	Solution of fractional Modified Kawahara type-2 equation	39
2.5	Results and Conclusion	42
2.6	A Maple implementation and graphs for Korteweg-de Vries and Kawahara Equations	42
2.6.1	A Maple code with 2D plot for the solution of KdV equation by RPSM at $x = 5$ and some fractional order α	42
2.6.2	A Maple code for Exact Solution of KdV equation and its 3D plot	44
2.6.3	A Maple code for the solution of KdV equation by RPSM technique which represent the 3D plot at different fractional order α	45
2.6.4	A Maple code with 2D plot for the solution of Kawahara equation by RPSM at $x = 5$ and some fractional order α	47
2.6.5	A Maple code for the solution of Kawahara equation by RPSM and its 3D plot at $\alpha = 1$	48
2.6.6	A Maple code for Exact Solution of Kawahara equation and its 3D plot	49
3	Homotopy perturbation Sawi transform method	51
3.1	Introduction	51
3.2	Preliminaries	52
3.3	Main Results	53
3.3.1	Homotopy Perturbation using Sawi Transform Method (HPSTM)	54
3.3.2	Convergence of HPSTM	56
3.4	Application of the HPSTM and Numerical Discussions	58
3.4.1	Solution of Time-fractional logistic equation	58
3.4.2	Solution of Time-fractional Fornberg-Whitham equation	60
3.5	Results and Conclusion	66

3.6	A Maple implementation and graphs for Logistic and Fornberg-Whitham Equations	66
3.6.1	A Maple code with 2D plot for the exact and approximate solution of Logistic equation by HPSTM at some fractional order α	66
3.6.2	A Maple code with 2D plot for the exact and approximate solution of F-W equation by HPSTM at some fractional order α	68
3.6.3	A Maple code for the solution of F-W equation by HPSTM technique which represent the 3D plot at different fractional order α	69
4	Homotopy perturbation General transform method	72
4.1	Introduction	72
4.2	Prerequisites	73
4.3	Homotopy Perturbation General Transform Method	76
4.4	Convergence of HPGTM	78
4.5	Applications	82
4.5.1	Radioactive decay model	82
4.5.2	Riccati equation	84
4.5.3	Backward Kolmogorov equation	87
4.5.4	Klein-Gordon equation	89
4.5.5	Rosenau-Hyman equation	95
4.6	Results and Conclusion	100
4.7	About Patent	100
5	Adomian Decomposition Shehu Transform Method with Caputo and Atangana-Baleanu Derivatives	101
5.1	Introduction	101
5.2	Preliminaries	103
5.3	Adomian Decomposition Shehu Transform Method	108
5.3.1	Flow Diagram of Proposed Scheme	108
5.3.2	Working of the ADShtM	109
5.3.3	Convergence of ADShtM	113
5.4	Numerical Application	115

5.5	Results and Conclusion	126
5.6	A Maple implementation and graphs for Sawada-Kotera-Ito Equation . .	126
5.6.1	A Maple code with 3D plot for the exact and approximate solution of Swada-Kotera-Ito equation by HPLTM at order $\alpha = 1$ by Caputo and ABC fractional derivative	126
5.6.2	A maple code for the comparison of the solution of Swada-Kotera- Ito equation by the Caputo sense, the ABC sense, and the exact solution at the values of $\alpha = 1, b = 0.1$ and $t = 4$	129
5.6.3	A maple code for the behavior of Swada-Kotera-Ito equation by the ADShTM with the different fractional order α and $b = 0.1$ in the ABC sense	130
6	Fractional-order COVID-19 model	131
6.1	Introduction	131
6.2	Preliminaries	135
6.3	Qualitative Analysis	136
6.4	Stability Analysis	139
6.5	Working of Homotopy Perturbation Laplace Transform Method	148
6.6	Approximate Solution of SEIR Model	150
6.7	Results and Conclusion	161
6.8	About Patent	161
7	Investigation of Fractional Diabetes model	162
7.1	Introduction	162
7.2	Preliminaries	165
7.3	Qualitative Analysis	166
7.4	Existence and Uniqueness	167
7.5	Stability Analysis	169
7.6	Working of Adomian Decomposition Laplace Transform Method	175
7.7	Solution of Diabetes Model	176
7.8	Results	185
7.9	Biological Interpretation	186

7.10 Conclusions	186
7.11 About Patent	187
References	188
List of Publications	209