SUMMARY

SWĀMĪ ŚRĪ BHĀRATĪ KIṢṆ A TĪRTHAJĪ MAHĀRĀJA, has given 16 Sūtras and 13 Sub-Sūtras which are written in a form of word formulae derived from Vedas. The researcher has tried to explain the meaning of Vedic Sūtras and Sub-Sūtras and applications by giving examples of each. Each formula deals with a different branch of Mathematics. Sūtras are very general and this is why they are so powerful and have such a wide range of applications. More research work in right direction needs to be done on each of these Sūtras summoning scholars from different fields to do research and decipher these. The world would surely find the right direction for exploring into advanced field.

7.1 SUMMARY AND CONCLUSION:

Chapter-1 Introduction and Mathematical Prerequisites:
In the 1st chapter of the thesis the researcher has explained about the founder of VM SWĀMĪ ŚRĪ BHĀRATĪ KIṢṆ A TĪRTHAJĪ MĀHĀRĀJA’s life and his Journey of finding Vedic Mathematics Sūtras and Sub-Sūtras with their meaning and also discussed the link of Vedic Sūtras and Sub-Sūtras to the Arithmetic, Algebra and Calculus by giving proper examples solved by using conventional method as well as through Vedic Mathematics by applying related Vedic Sūtras & Sub-Sūtras. Then the scope and the importance of Vedic Mathematics is explained. After the comparison the method by using Vedic Sūtras and Sub-Sūtras with the conventional method, the researcher finds that the conventional methods are lengthier, complicated and time consuming than the method by using Vedic Sūtras. If one has the knowledge of the Vedic Sūtras and Sub-Sūtras and their applications to the particular problem then by using it he/she can solve the problem within a few seconds without writing so many steps and in an easy way. That is why Vedic Mathematics Sūtras and Sub-Sūtras can be very useful for the student’s appearing for competitive exams. First chapter concludes with the outline of the thesis.

Chapter -2 Literature review:
Literature review is very important part of the thesis which inspired the researcher to select the topic. The current research was based on secondary data. Researcher has studied past research papers, research journals, books and other theses related to the current research topics. After studying the above materials, the researcher has found that majority of the research has done in the field of computer science by applying the Vedic Sūtras and Sub-Sūtras for binary subtraction, Multiplication, Division as well as in binary squaring and Cubing. Also research has been done in the comparison of conventional method with the Vedic mathematics by giving two different groups of students, problems at primary level; one group had to solve the problems by conventional method and another group had to solve them by Vedic Mathematics. Very few (hardly one or two) research papers were found on applications of Vedic Sūtras and Sub-Sūtras in Quadratic equations, Factorization as well as advance level topics like Determinant and Matrices, Derivatives, Integrations and Solutions of Ordinary and Partial Differential equations. Such a research gap which the researcher addresses as sufficient research work has not being done in the above topics. So it was very challenging task for the researcher. After reading the books related on Vedic Mathematics, the researcher has found two books more interesting, useful and informative in terms of the content to which give more weightage to Vedic Maths. 

The book ‘Vedic Mathematics’ by SWĀMĪ ŚRĪ BHĀRATĪ KṚṢṆ A TĪRTĀJĪ MAHĀRĀJA, Śankarāchārya ṢṆ of Govardhana Matha, Puri, Edited by Dr. V. S. Agrawala and also the book ‘Vertically and Crosswise’-Applications of Vedic Mathematics Sūtras by Pickles, Nicholas & Williams; both the books were found very useful as well as the study of Literature review found very helpful for the current research topics by the Researcher.

Chapter-3 Solution of Quadratic, Cubic and Quartic Equations:

In this chapter solutions of special types of Quadratic equations are explained by using Vedic Sūtras: Śūnyam Śāmyasamuccaye, Vilokanam, Ānurūpye Śūnyamanyat& Parāvartya Yojayet. Also factorization of Quadratic expression with one variable (x) and with two variables (x & y) by using Ānurūpyeṇa & Ādyamadhyenāntyanantyena Sub-Sūtras are explained by giving proper examples for each. The easiest method of factorization of long homogeneous quadratic expression with three variables (x, y & z) by using two Sub-Sūtras Ādyamadhyenāntyanantyena & Lopanasthāpanābhyām are explained by taking examples. First by using Lopanasthāpanābhyām by eliminating any two variables (substituting zero to
one variable at a time) out of three and retaining in the remaining two variables which can be factorized by using Ādyamadṛṣṭamāntyaṃantyaṃ. Thus, to get real factors of long expression fill the gaps of already obtained the above two set of factors. Similarly, factorization of long homogeneous quadratic expression with three variables and one independent term as well as with four variables are explained by giving proper examples for each by using Ādyamadṛṣṭamāntyaṃantyaṃ, Lopanasthāpanābhyaṃ Sub-Sūtras in which three eliminations are done by eliminating two letters (substituting zero to two letters at a time) and factorized the obtained results. Thus with this obtained three sets of factors, by filling gaps real factors of long expression is obtained. The method of factorization by using Vedic Sūtras was found easier than the time consuming current method.

Chapter-4 Determinant and Matrices:
In this chapter by introducing Determinant and Matrices along with their inter relationship, evaluation of above parameters for second, third and fourth order has been explained by conventional method and then by vertically & crosswise. For third and fourth order by using conventional method after writing so many steps evaluation can be done which may be time consuming but by using Vedic Sūtra the same evaluation can be done within a single step without writing so many steps. The same procedure of finding determinant is applied to find Adjoint, Inverse & Rank of a matrix. Evaluation of special types of determinant extracting one, two or three elements by using Vedic Sūtra by elimination and retention has been explained with proper examples. Applications of determinant in solving simultaneous linear equations, finding non-zero solution of linear homogeneous equations and to check the consistency of linear algebraic equations are explained nicely by giving examples of each. Area of triangle can be found out by using determinant and also the condition of being three points collinear are explained. It is found that for the evaluation of second order determinant there was not much difference in writing steps by using conventional as well as Vedic Sūtra but the same for third and fourth order by using Vedic Vertically & Crosswise Sūtra very quickly compare to the conventional method.

Chapter -5 Derivative, Integration and Solving Ordinary and Partial Linear and Non-linear Differential Equations:
In this chapter Derivative and Calana-Kalanābhyām, Differential Calculus has been explained by using Guṇaka-Samuccayaḥ Sūtra. According to the Sūtra, for quadratic equation if we can factorize in two linear factors then by adding that two factors the first differential $D_1$ is obtained.

\[ i.e. D_1 = \sum a \text{ & } D_2 = 2! \]

For cubic expression we can factorize into three linear factors then differentials are:

\[ D_1 = \sum ab; D_2 = 2! \sum a \text{ and } D_3 = 3! \]

For bi-quadratic expression we can factorize them into four linear factor then,

\[ D_1 = \sum abc; D_2 = 2! \sum ab, D_3 = 3! \sum a \text{ and } D_4 = 4! \]

By using the above Sūtra, the process of factorization is possible for the greatest degree in any variable.

Finding differentiation value to functions related to each other arithmetically both by conventional method and also by using Vertically & Crosswise Sūtra are explained with proper examples and line diagrams. Also 2nd order, 3rd order and 4th order derivatives of the given functions are explained by using binomial theorems and Vertically & Crosswise Sūtra. Problems of Integrations based on Integration of multiplication of two functions and based on partial fractions of the different types; in which denominator containing linear and unrepeated factors, denominator containing linear and repeated factors and denominator containing the quadratic equation which cannot be factorized further three types of problems solved by using conventional method as well as by using Parāvartya Yojayet & Viloknam Sub-Sūtra. Solution
of ODE & PDE for linear as well as nonlinear type are explained with Taylor series and Maclaurin’s theorem and by using Vedic Sūtra ‘By alternate elimination and retention’.

Integral equations ‘By alternate elimination and retention’ Sūtra and Digression: Differentiation of the ratio of the polynomials by using Vertically & Crosswise Sūtra. Ordinary and partial differential equations by using ‘By alternate elimination and retention’ and nonlinear equations by using Duplex property of Vertically & Crosswise Sūtra and ‘By alternate elimination and retention’ Sūtras are explained with examples.

Chapter-6 Applications of Vedic Sūtras in Computer Arithmetic:
An important part of CPU is Arithmetic Logic Unit (ALU) by which the actual mathematical operation like Addition, Multiplication, Division, Squaring and Cubing for each instruction is performed which are used frequently in hardware level for Fast Fourier Transform, Convolution & Filtering which are applications of Digital Signal Process. Additionally, squaring and cubing are used in Cryptography, Animation, and image processing etc. where the speed is a crucial performance characteristic.

The binary system is internal language of computer which has base 2 i.e. it uses only two bits 0 and 1. Conversion method of Binary to Decimal number, decimal to binary number and Two’s complement of a binary number are explained with examples. In this chapter the researcher has explained arithmetic operations in binary number system by giving one example of each. Just like a decimal number system the arithmetic operations are performed in binary number system. Different types of multipliers and Division algorithms are used for binary operations. Therefore, it is necessary to have efficient multiplier in terms of great rapidity, less power consumption, accuracy and occupies less number of slices.

In this chapter applications of Vedic Sūtras in computer arithmetic binary operations by using related Vedic Sūtras with their algorithms are explained. Vertically & Crosswise Sūtra based multiplier is used for all types of multiplications by giving examples of 2 x 2 bit, 4 x 4 bit, 8 x 8 bit; for special type of binary multiplication Sūtras like Nikhilam, Ekanyūnena Pūrveṇa & Ānurūpyeṇa Sub-Sūtra based multiplier are used. For all types of binary division Dhvajaṇka; to solve larger class of problem of binary division Parāvartya Yojayet and for the numbers
which are near to base 10 Nikhilam based algorithm are applied. For binary squaring Dwandwayoga means Duplex property of Vertically & Crosswise Sūtra and Yāvadūnam Sūtra based squaring architecture; for binary cubing Yāvadūnam Sūtra and Ānurūpyeṇa Sub-Sūtra based cubic architecture are discussed by the researcher.

There are conventional multipliers like Booth, Wallace Tree, Combinational and Array & Sequential Multiplier. It was found that Vedic multiplier, for squaring and cubing architecture based on Vedic Sūtras is the most efficient multiplier which gives quick output, covers less space & intakes less power compared to conventional Multiplier.

CONCLUSION:

Vedic Mathematics Sūtras can be effectively used in basic as well as in higher mathematics.

In this age of cut throat competitions & the necessity for overall excellence, recruiters too have transformed their hiring process to account for these factors. Apitude tests often serve as initial screening to the highly sought positions in academia as well as industries. VM approach has time and again proved to offer a huge advantage in preparation for these events as well as for an individual’s holistic development.

Intrinsic sūtra mathematics is useful in bringing back fun and interest of students in an abstruse subject like Mathematics. A systematic and developed study of Vedic Mathematics will be extremely useful for students and researchers.

The modern teaching of one way calculations are rigid and boring. Vedic Mathematics has general methods and also many methods that apply for special cases. These calculations can often be carried out independent of direction & orientation. Because of this flexibility, students can use their own approach which promotes creativity and intuition. In this rapidly changing world, flexibility and adaptability are absolutely essential for success.
By using **Vedic Sūtras** complicated and lengthy computations can be solved with greater accuracy and lesser time as compared to calculations based on conventional maths. VM also improves memory and creates greater mental alertness.

The most significant quality of Vedic Maths is its consistency. Because of this quality it creates stress-free and enjoyable environment. It inspires innovations. The beautiful coherence between arithmetic and algebra is clearly visible in the Vedic system.

Vedic algorithms based on **Ūrdhva-Tiryagbhāyām Sūtra, Nikhilaṁ Sūtra & Ānurūpyeṇa Sub-Sūtra** etc. can be applied to design great rapidity Vedic Multipliers & reconfigurable Fast Fourier Transform (FFT) in DSP.

**7.2 RECOMMENDATION:**

Though Vedic maths, demands regular practice of simple problems, even a little exposure to the Vedic maths approach, coupled with some practice, clearly has immense added advantage as it develops a novel & instinctual approach to problem solving.

The impression that has been created over the years has put VM in a bad light reducing it to abstract hacks to special types of quantitative problems for which one has to memorize innumerable conditions, relations and operations. Large scale education programs to promote intrinsic logical approach will go a long way in popularizing what our ancestor knew way back & which is now being explored by the western world.

Inclusion of Vedic Mathematics in the curriculum right from the first standard will undoubtedly change the present attitude of students towards Mathematics as it allows for creative usages.

Researcher would like to highlight that we must try to develop the spirit of Vedic Mathematics in all upcoming computations and technologies by building upon the foundation work done in exploring the Contributions of Vedic Mathematics in Advance Calculus.
The propagation of Vedic Mathematics can be encouraged by conducting National Seminars and International Seminars at the Academic & Research level showcasing the applications of Vedic Mathematics in Computers.

Computers have entered in all areas of our life from banking, technology, transportation to education. Thus, there is a scope to apply powerful sutras in unexplored domains and scientific research for convenience and overall well being of humans.

By using the technology of Very Large Scale Integration i.e. VLSI with Vedic Sūtra designing and show casing Vedic DSP Chip is a very promising area for future applications of Vedic Sūtras.

7.3 FUTURE SCOPE IN CURRENT RESEARCH:

Going unrecognized & underappreciated for nearly a century, VM approach has risen in reputation among both intellectuals as well as schoolchildren primarily due to its flexibility. The freedom to approach a problem without the constraints of unconsciously abiding to a predefined set of abstract rules offers unparalleled opportunities in areas of scientific research & radical discovery in Information Technology.

When people are given an option to educate themselves through a self defined pace and are given access to resources that encourage development of their innate capabilities, they learn fast and retain more information and moreover get things done independently. This develops a sense of satisfaction in addition to making the previously boring quantitative studies exciting and enriching.

Further the Ūrdhva-Tiryagbhyām Method of solving linear simultaneously equation can be used for solving even 8 or 10 unknowns using the Pivoting techniques.

Previous researchers have limited their application domain mainly towards astronomy and classical mechanics. However with the rise in supercomputers, quantum computing and machine
learning, the effective sūtra algorithms may work wonders as they perfectly fit the current needs of these trending technologies.

Further big data and analytics involve predictive modelling of infinite data generated globally in order to make business decisions. This online information helps companies better understand their consumer needs and help them meet their expectations while fulfilling the organizations objective of productivity. VM could play an instrumental role in bringing these proposed technologies soon to reality.

VM creates a deeper understanding about the matrix of using computer generated translations and human language through the field of artificial intelligence. A study of Vedic maths is not only immediately useful but holds a lot of scope for further development and research.

7.4 LIMITATIONS:

This thesis has given more applications about the techniques of Vedic Mathematics-applied to Arithmetic, Algebra and Calculus and also to Computer Arithmetic. It does not discuss about the source of Vedic Mathematics.

The solutions of matrix problems by **Vertically & Crosswise Sūtra** are applicable to only the types which are based on determinants. The Vedic concepts may be very strong but the concepts cannot be generalized.

In Differential calculus, **Vedic Sūtras** are applied to the problems of derivatives and successive differentiation based on Polynomial functions only. However, the problems of derivatives of product of two functions and three functions can be solved by using **Vertically & Crosswise Sūtra** along with the help of binomial theorem and the knowledge of standard Derivative formulae of conventional mathematics. Integration by parts by using **Vertically & Crosswise Sūtra** and integration based on partial fraction by using **Parāvartya Yojayet Sūtra** can be faster in comparison to standard Integration methods. But for any other types except for the above two type’s problems on Integration we have to rely on standard formula of Integration.
There are a very few research papers focusing solely on Contribution of Vedic Mathematics in Advance Calculus, hence the researcher did not have the privilege to have an access to a wide range of information.

Although there are various obstacles and limitations currently to employ the techniques of Vedic mathematics in applications involving lengthy and time consuming computations, these hindrances pose a challenge for future researchers to make this area of research interesting and encouraging