Blending of Traditional Approach and Internet Technology to Teach Engineering Mathematics

Vipul R Shah, Rajesh C Sanghvi
vipulshah@gcet.ac.in
rajeshsanghvi@gcet.ac.in
G H Patel College of Engineering & Technology,
Vallabh Vidyanagar, Anand, Gujarat, India

Abstract: *Mathematics is an integral part of the study of engineering regardless of which branch of engineering is chosen. In this article, we suggest a blending of analytical approach and use of internet technology for interactive teaching of computationally oriented undergraduate engineering mathematics. In recent years, an increasing number of web sites have offered significant material which is publically available. We believe that integrating the traditional method, such as with chalks and black board, with screen projections from the web pages for better visualization surely increases depth of content knowledge and pedagogy through inquiry and reflective practices.*

In this paper, we shall discuss how internet technology is useful for some of the topics like differential equations, linear algebra, numerical methods, of engineering mathematics while teaching in a class. There are numerous sites explaining the concepts in depth as well as providing examples related to field in different branches of mathematics. Students can learn the material themselves also. Video lectures delivered by experts in the field to the students of recognized institutes are also available on the internet. Many e-books are also freely downloadable.

Introduction

A sound understanding of basic mathematical concepts is highly essential for an engineer especially working in Research and Development Department of majority of engineering fields. For example, an engineer working on some vibration problem must have thorough knowledge of ordinary and partial differential equations, Fourier series and Fourier Transforms, Laplace Transforms, Numerical methods, etc. Similarly, an electrical and electronics engineer requires the understanding of almost all mathematical concepts, varying from the factors of a polynomial to optimization of a nonlinear function with several constraints. A computer engineer needs to learn Discrete Mathematics, Number Theory, Solid Geometry, etc. It is a different issue that should we teach all concepts of engineering mathematics, even if they are irrelevant to their branch, to every student of engineering.

Despite of the fact that Mathematics is highly essential for the strong foundation of engineering, students are less interested in mathematics. Their approach towards learning mathematics, remains limited to solving problems mechanically and pass the subject, if possible, with higher grades. From the experiences of teaching students at degree engineering level, we reveal that some of the mathematical concepts are difficult to grasp. As an example, consider the concept of a limit. Using only blackboard, students with sufficient passion can learn mechanically to find the limit. But, there is no guarantee that they even have understood the concept. Of course, effect of changing epsilon on delta can be explained by drawing several graphs. But, there are limitations regarding time, drawing ability of the instructor, etc. Similarly, the concepts which require geometrical

visualization, such as area between curves, the volume bounded by intersection of two or more surfaces are difficult for the instructor to convey.

ICT tools are highly useful in such cases. These cognitive tools influence the way we develop mathematical concepts and connections. They are reorganizers rather than amplifiers. If the thinking of the learner qualitatively gets transformed when he interacts with technology, it should be called reorganization [1]. Software and websites provide a learning environment for exploration and investigation. They integrate different representations and stimulate reflection. As per the quote of Veteran Teacher at Scales, "Technology truly transfixes the student's focus. They are 100 percent engaged. They are so engaged, they don't even realize how much of the curriculum is tied in" [2].

However, ICT tools should be considered as supplementary tools. They should not be considered as complete replacement of the blackboard work. In fact, by collecting the opinions of several students and faculties, we realize that students remain conscious while solving problems on blackboard and hence better understand the technique of solving the problem. There was a negative opinion towards power point presentations also, especially in the subject of mathematics. So, we suggest a blending of the two approaches. The exhaustive list of ICT tools is clearly impossible. This paper highlights some of the ICT tools freely available at different sites.

Some of the known ICT tools

We discuss here applets and animations, video lectures and e-books as ICT tools, useful in different branches of mathematics.

Applets and animations

Calculus The applet given at [3] demonstrates understanding of what it means for a function to have a limit at a point and calculate limit of functions.

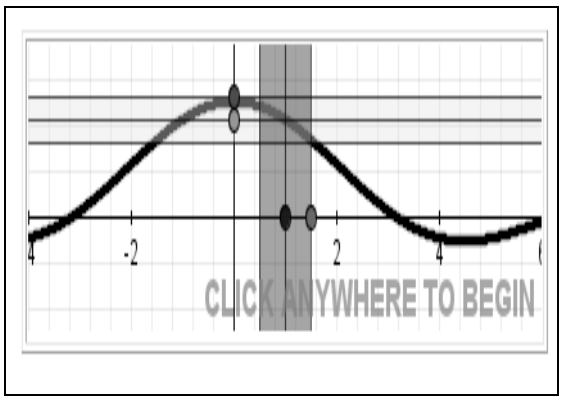


Fig.1 Epsilon and delta regions

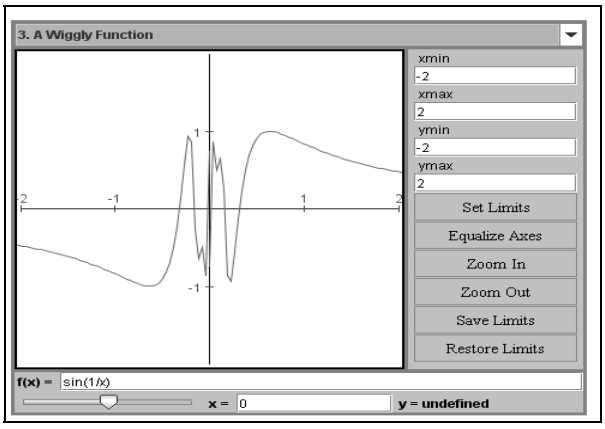
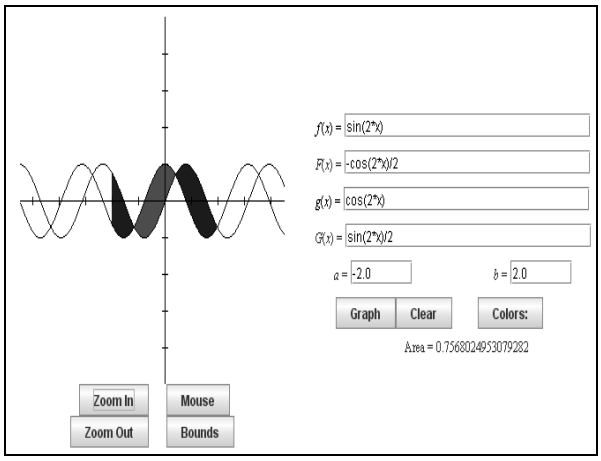


Fig.2 A discontinuous function

It shows the regions representing the epsilon neighborhood (yellow region) and delta neighborhood (blue region) for different values of epsilon and delta (Fig.1) Similarly, the applet given at [4]

demonstrates the functions having different types of discontinuities. The graph of a wiggly function is shown in Fig.2.

The following figures are snapshots of the applets demonstrating the area between two curves [5] and volume bounded by revolution of a surface [6].



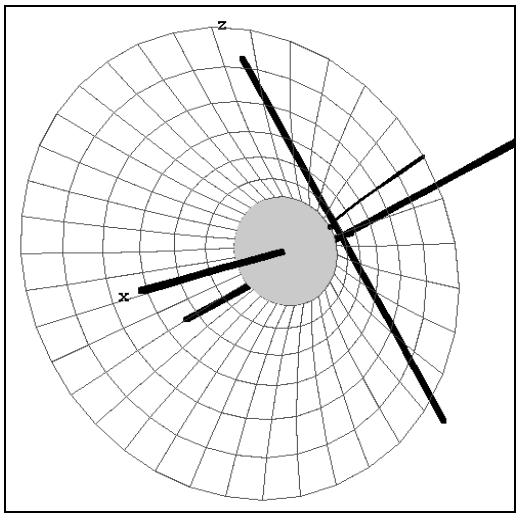


Fig.3 Area between two curves

Fig.4 Volume of revolution of a surface

Graphing Calculator

Graphs explain the behavior of the function clearly. But manually drawing the graph on blackboard is time consuming and there are higher chances of inaccuracy. So, generally teachers avoid drawing the graphs. As a result, student's familiarity with some of the standard functions remains poor.

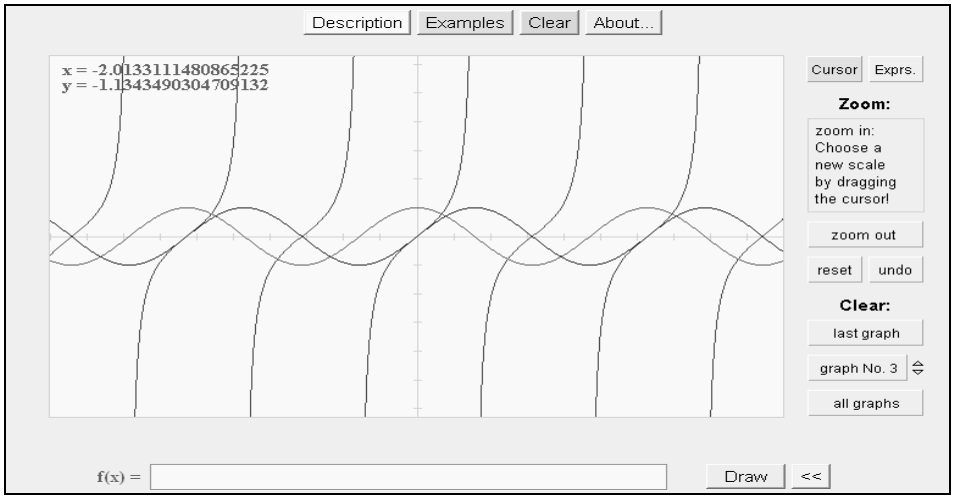


Fig.5 Graphing Calculator

However, the graphing calculator available at [7] is useful to draw the graph of any function.

Theory of Transforms

The animation available at [8] demonstrates the convergence of Fourier Series. The animation shows the effect of adding terms one by one. After certain number of terms, the graph of the sum of terms coincides with the graph of the original function, which indicates that the series converges to the given function. Fig.6 shows the graph of the function having sum of 13 terms of the Fourier series representing the constant function $f(x) = 1$.

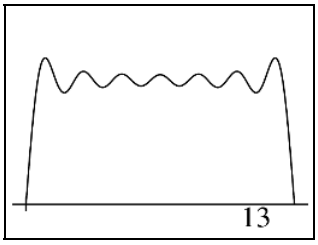


Fig.6 Fourier Series Animation

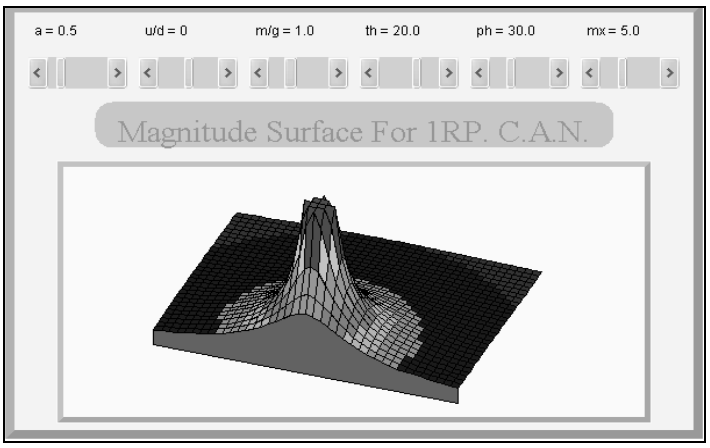


Fig.7 Magnitude Surface by Laplace Transform

The applet available at [9] shows a surface plot of the magnitude of the Laplace Transform of a system with a pole at –a (Fig.7).

Differential Equation

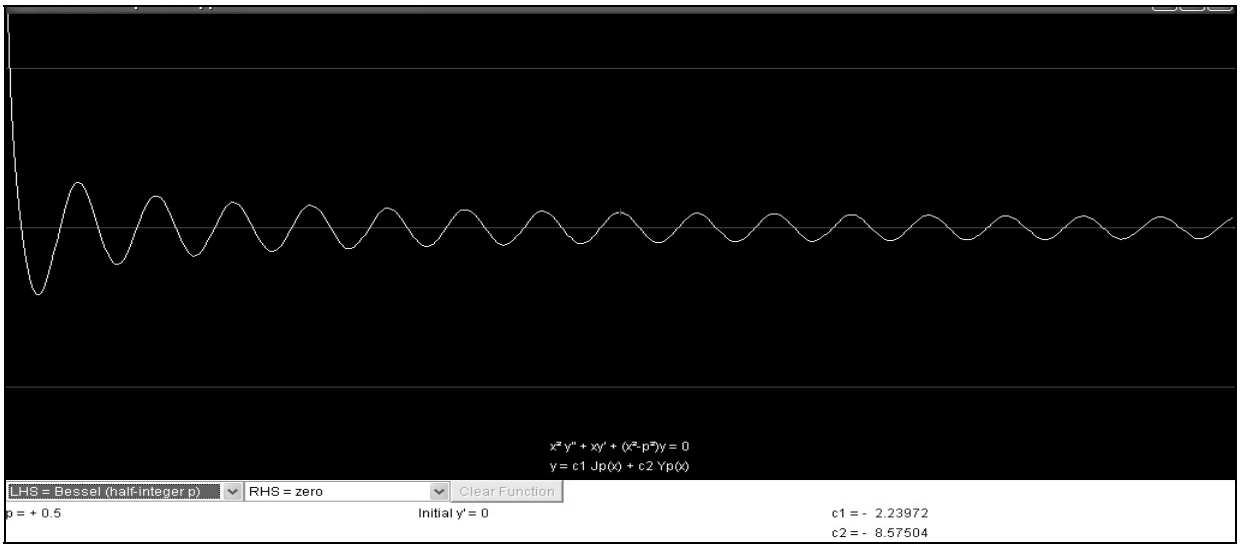


Fig.8 Solution of Bessel's equation with $p = 0.5$

The applet in Fig.8 shows the solution of the Bessel's equation with a particular value of p and with specified initial condition [10].

Matrix Algebra

Matrices are useful in transformations such as reflection, rotation, etc. The effects of applying such transformations on a point are better visualized by the applet available at [11]. (Fig.9)

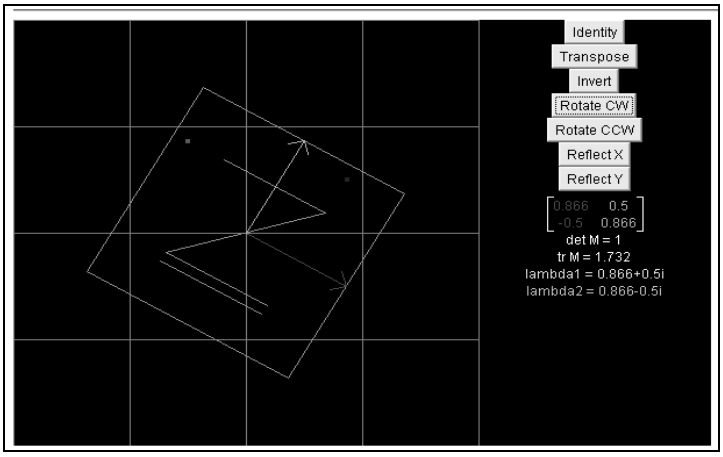
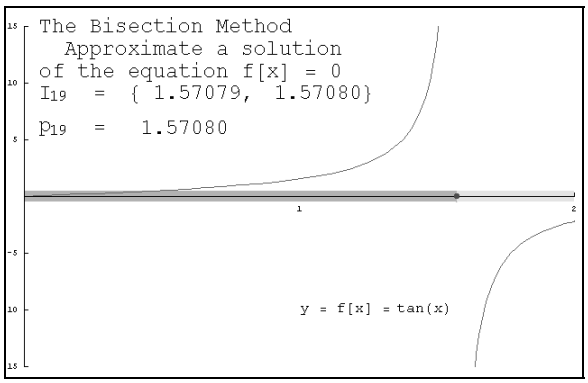


Fig.9 Matrix Transformations

Numerical Methods

The applets available at [12] indicate the convergence of approximations by Bisection Method (Fig.10) and curve fitting by Lagrange and Newton Polynomials, respectively. (Fig.11)



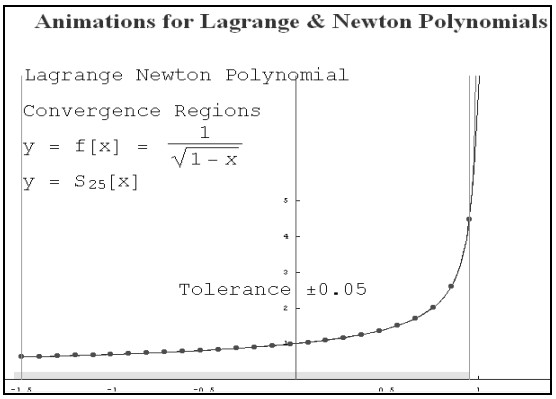


Fig.10 Bisection Method

Fig.11 Lagrange and Newton Polynomials

Sequence and series

The applet available at [13] given in Fig.12 shows the comparison test for two series. The applet given in Fig.13 shows the graph of the values of a sequence and the partial sums of the sequence.

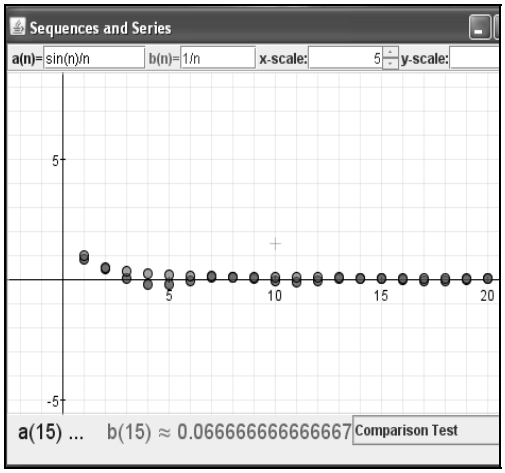


Fig.12 Comparison test

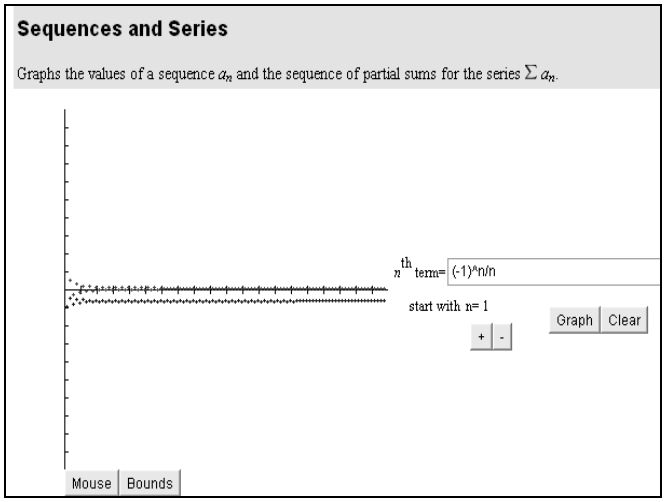


Fig.13 The terms of a sequence and its partial sums

Complex Analysis

The following applet[14] shows the composition of the airfoil with a cubic function.

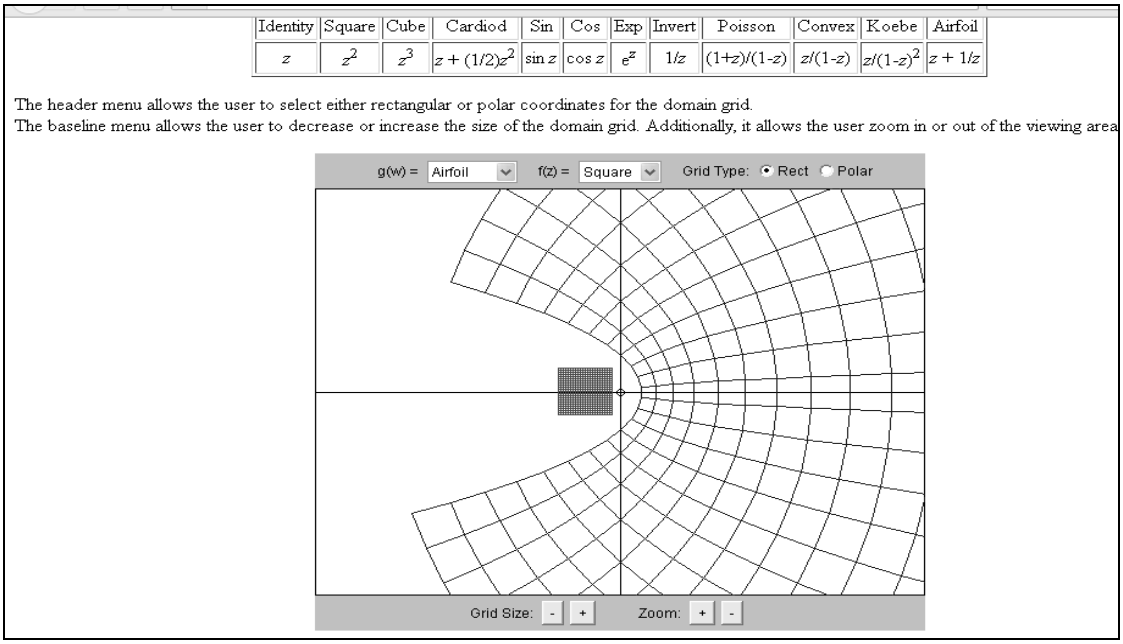


Fig.14 Composition of Airfoil with a square function

Video lectures

An important site for web courses is [15]. It is the site of National Program on Technology Enhanced Learning (NPTEL) funded by Ministry of HRD, Government of India. The site offers 1016 web courses pertaining to different disciplines of engineering including mathematics.

Fig.15 A video lecture at NPTEL

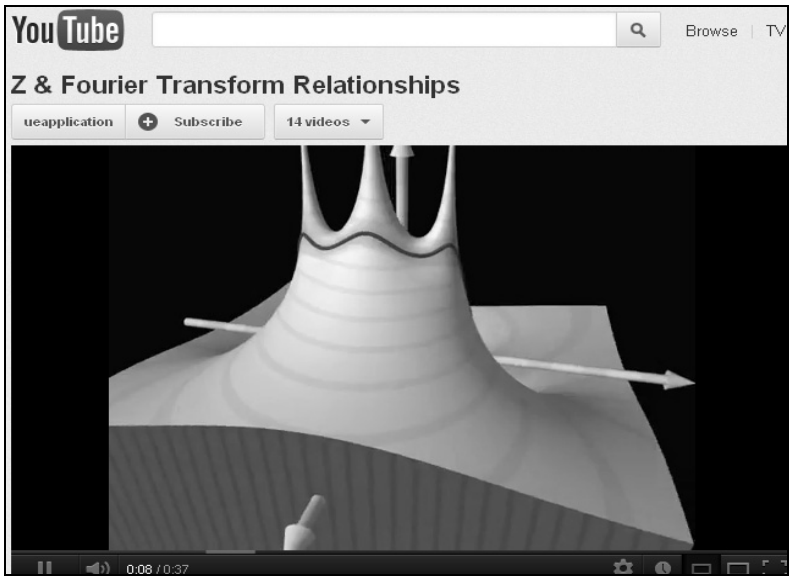


Fig.16 z and Fourier Transform Relationships

There are many video lectures available at [16] for almost all topics in nearly every subject. Fig.16 is a snapshot of one such video lecture which describes the relationship between z transform and Fourier transform.

Free e-Books

Every book reflects a different perspective of the author about the content. That is why, referring different books on the same topic may enhance our understanding. Besides, different examples on the same topic are also helpful in this matter. So, free e-books are worth to look at. Some of the sites where such books available are [17,18].

Conclusion

We conclude our paper by observing that many of the topics we discussed are better understood if ICT tools are used. It is difficult and time consuming, if not impossible, to visualize these concepts using only black board. However, keeping in mind, the general opinion from the students, we believe that the mathematical steps involving simplification of equations are better understood using blackboard. So, we suggest the blending of the two approaches. More specifically, ICT tools can be used for the interpretation of the results. In this sense, ICT tools play a supplementary role in enhancing the understanding.

Acknowledgement

We are thankful to G H Patel College of Engg. & Tech. , Vallabh Vidyanagar, Gujarat, India for providing us the facilities and the resources necessary to prepare the paper. We are also thankful to Prof Kumar Trivedi for helping us download various applets.

References

[1] Anne Berit Fuglestad, Student's use of ICT tools : Choices and Reasons, Proceedings of the 29th Conference of the International Group for Psychology of Mathematics Education , Volume 3 Department of Science and Mathematics Education, University of Melbourne, 2005.
[2] Science, Technology, Engineering and Math, SETDA, September 2008 , Stakeholder Advisory Committee Roundtable Meet Report.
[3] http://www.math.psu.edu/dlittle/java/calculus/
[4] http://calculusapplets.com/limitsfail.html/
[5] http://cs.jsu.edu/~leathrum/Mathlets/twocurves.html
[6] http://www.math.umn.edu/~rogness/mathlets.shtml
[7] http://www.math.com/students/graphing.html
[8] http://www.physics.miami.edu/%7Enearing/mathmethods/square-sine-series.html
[9] http://cnyack.homestead.com/files/alaplace/lt1rpm.htm
[10] http://www.falstad.com/diffeq/
[11] http://www.falstad.com/matrix/
[12] http://www.math.fullerton.edu/mathews/n2003
[13] https://wiki.eee.uci.edu/index.php/Sequence_&_Series#Annotated_References
[14] http://www.math.ttu.edu/~pearce/complex/complexviewer.html
[15] http://www.***nptel***.iitm.ac.in/
[16] http://www.youtube.com/
[17] http://www.getfreeebooks.com/?tag=mathematics
[18] http://www.freebookcentre.net/
[19] Sudhir R. Ghorpade, Teaching Calculus using Internet : Some Experiments and Experiences, Department of Mathematics, Indian Institute of Technology, Bombay, Powai, 400 076, India.
[20] Sarmite Cernajeva, Irina Eglite, Use of Information and Communication Technologies in Mathematics studies in Engineer Education at the Riga Technical University Riga.
[21] Flores, A., Knaupp, J.E., Middleton, J.A., & Staley, F.A. (2002). Integration of technology, science, and mathematics in the middle grades: A teacher preparation program Contemporary Issues in Technology and Teacher Education [Online serial], 2(1).