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Compactness of the Unit Ball

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Our aim is to present to students the significance of compactness of the unit ball in the norm, weak, weak * topologies in a normed linear space (henceforth abbreviated as n. l. s) . Hereafter X shall denote a n. l. s. We have the following notations:

The unit ball of X is $B(X) = \{x \in X : \|x\| \leq 1\}$.

The unit sphere of X is $S(X) = \{x \in X : \|x\| = 1\}$.

The space of bounded (continuous) linear functionals on X is X^* with norm

$$\|f\| = \sup\{|f(x)| : \|x\| \leq 1\} = \sup\{|f(x)| : \|x\| = 1\}.$$

Here X^* is called the dual of X. For $A \subseteq X$, $\langle A\rangle$ stands for the linear span of A.

We recall the **Riesz Lemma** for convenience:

Riesz Lemma: If Y is a proper closed linear subspace of a n.l.s X and $0 < r < 1$, then $\exists\, x \in S(X)$ such that $\|x - y\| \geq r \ \forall \ y \in Y$.

First, for the norm topology, we have

1. Proposition. *$B(X)$ is compact (in the norm topology) iff X is finite dimensional.*

Proof. If X is finite dimensional, it is homeomorphically isomorphic to $\mathbf{R}^n$ or $\mathbf{C}^n$ and hence the compactness of the unit ball follows from the Heine–Borel theorem.

For the converse, suppose X is infinite dimensional.

Fix $x_1 \in S(X)$.

Since $X \neq \langle x_1\rangle$, by Riesz Lemma, $\exists\, x_2 \in S(X)$ with

$$\|x_2 - x_1\| \geq 1/2.$$

Since $X \neq \langle x_1, x_2\rangle$, $\exists\, x_3 \in S(X)$ with

$$\|x_3 - x_1\| \geq 1/2, \|x_3 - x_2\| \geq 1/2.$$

Proceeding this way, we get a sequence $\{x_1, x_2, \ldots\ldots\} \subseteq S(X) \subseteq B(X)$ with

$$\|x_i - x_j\| \geq 1/2 \quad \text{for} \quad i \neq j.$$

Then $\{x_n\}$ does not have a convergent subsequence. Therefore, $B(X)$ is not compact. □

Next we move to the weak-topology on X and the weak*-topology on X^*.

2. Definition. The weak topology on X is the smallest topology on X with respect to which every $f \in X^*$ is continuous.

In terms of convergence of nets, $x_\alpha \to x$ weakly in X iff $f(x_\alpha) \to f(x) \,\forall\, f \in X^*$.

3. Remark. Since X^* is also a n.l.s, X^* too has the weak-topology on it.

4. Notation. For every $x \in X$, we have the evaluation functional $\hat{x}$ on X^* defined by $\hat{x}(f) = f(x)$.

5. Remark. Since $|\hat{x}(f)| = |f(x)| \leq \|f\| \, \|x\|$, we get $\|\hat{x}\| \leq \|x\|$. By Hahn–Banach theorem,

$$\forall\, x \in X, \exists\, f \in S(X^*) \quad \text{such that} \quad f(x) = \|x\|. \qquad (*)$$

That is, $\hat{x}(f) = \|x\|$ with $\|f\| = 1$. i.e., $\hat{x}$ attains its norm on $S(X^*)$. Therefore, $\|\hat{x}\| = \|x\|$.

6. Remark. The map $x \to \hat{x}$ embeds X isometrically isomorphic in $X^{**} (= (X^*)^*)$.

With this embedding, if $X = X^{**}$, we say X is reflexive.

For instance, lp, for $1 < p < \infty$, are reflexive spaces.

7. Remark. That the dual of observation (*) in (5. Remark) characterizes reflexive spaces is James Reflexivity theorem: $\forall f \in X^*, \exists\, x \in S(X)$ such that $f(x) = \|f\|$ iff X is reflexive.

8. Definition. The weak*-topology on X^* is the smallest topology on X^* with respect to which every $\hat{x} (x \in X)$ is continuous.

In terms of convergence, $f_\alpha \to f$ weak* in X^* iff $f_\alpha(x) = \hat{x}(f_\alpha) \to \hat{x}(f) = f(x) \,\forall\, x \in X$.

Note that the weak*-topology is defined only on a dual space X^*.

9. Remark. From the definition of these three topologies, we have the following containments:

$$\text{weak topology} \subseteq \text{norm topology}.$$

Further on a dual space, weak* topology ⊆ weak topology.

That these containments could be strict can be seen from the following examples:

(i) $e_n \to 0$ weakly in c_0; however $e_n \nrightarrow 0$, since $\|e_n\| = 1\,\forall\, n$.
(ii) $e_n \to 0$ weak* in $l_1 = c_0^*$; however, $e_n \nrightarrow 0$ weakly.

For verifying the above examples, let us recall that the dual actions are

$$\{a_k\}(\{b_k\}) = \sum_k b_k\, \overline{a}_k$$

in the case of $c_0^* = l_1$ and $l_1^* = l_\infty$.

For the compactness of the unit ball in the weak* topology, we have

10. Proposition. (Banach–Alagolu theorem):
$B(X^*)$ is weak - compact for any dual space X^*.*

Proof. Consider the map $J : f \to (f(x))_{x\in X}$ from $B(X^*)$ to $\prod_{x\in X} [-\|x\|, \|x\|]$ if X is a real n.l.s and from $B(X^*)$ to $\prod_{x\in X} B_x$ if X is a complex n.l.s. [Here B_x is the closed disk in the complex plane with centre 0 and radius $\|x\|$]. Note that by Tychonoff's theorem, the product space $\prod_{x\in X} B_x$ is compact.

Clearly J is one-one.

$$f_\alpha \to f \text{ weak}^* \quad \text{in} \quad B(X^*) \Leftrightarrow f_\alpha(x) \to f(x) \forall x \in X.$$
$$\Leftrightarrow (f_\alpha(x))_{x\in X} \to (f(x))_{x\in X}.$$

Therefore, J on $B(X^*)$ and J^{-1} on the range of J are continuous.

Next we show that the range of J is closed. Suppose

$$J(f_\alpha) \to (y_x)_{x\in X}.$$

Then $f_\alpha(x) \to y_x \,\forall\, x \in X$. Define f on X by

$$f(x) = y_x.$$

Clearly f is linear; $|f_\alpha(x)| \le \|x\| \forall\, \alpha$ and so $|f(x)| \le \|x\|$. Hence $f \in B(X^*)$. Therefore,

$$(y_x)_{x\in X} = (f(x))_{x\in X} = J(f).$$

Hence range of J is closed. Thus J embeds $B(X^*)$ with the weak*- topology as a closed subset of a compact product space. Therefore, $B(X^*)$ is weak* - compact. □

Finally for the compactness of the unit ball in the weak topology, we have

11. Proposition. *$B(X)$ is weakly compact iff X is reflexive.*

Proof. If X is reflexive, clearly the weak and the weak*-topologies coincide on X and hence $B(X) = B(X^{**})$ is weakly compact, by Banach–Alagolu theorem.

Conversely let $B(X)$ be weakly compact. Then every $f \in X^*$, being continuous on the compact set $B(X)$, attains its supremum on some $x_0 \in B(X)$. i.e., $f(x_0) = \|f\|$. Then

$$f\left(\frac{x_0}{\|x_0\|}\right) = \frac{f(x_0)}{\|x_0\|} = \frac{\|f\|}{\|x_0\|} \ge \|f\|.$$

By definition of $\|f\|$, $f\left(\frac{x_0}{\|x_0\|}\right) \le \|f\|$.

$$\therefore \quad f\left(\frac{x_0}{\|x_0\|}\right) = \|f\|.$$

Thus every $f \in X^*$ attains its norm on $S(X)$.

By James Reflexivity theorem, X is reflexive. □

12. Remark. Usually one uses Hahn–Banach separation theorem in the above proof. Instead , we have preferred to use James theorem, for the sake of a short proof of 11. Proposition.

The proof of James theorem is quite involved. For a proof, see James, R.C. – Weakly compact sets, Trans. Amer. Math. Soc., 113, p. 129–140, 1964.

The Story of Fourier Series

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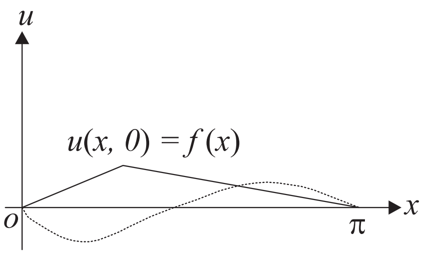
Abstract. In this story of Fourier series we shall see their conception, growth and contributions to other part of mathematics. We shall only consider classical Fourier series, not any other further developments or generalizations. Two problems from physics, namely, the vibrating string and heat conduction in solids, were the impetus for Fourier series. The search for solutions or what it means to be solutions for these two problems has been the source for the development of many important concepts and ideas in mathematics. It is an educational experience to know that even the masters had great difficulties with mathematics in understanding and shaping it in the above process. We shall walk through some of the major historical paths and meet some of the major players in the development of solutions of the above problems and other concepts. This will be only an historical tour and the details of the mathematics can be found elsewhere.

1. Vibrating String Problem

Jean Le Rond d'Alembert 1717–1783



Let us consider an elastic string which is stretched tightly between $x = 0$ and $x = \pi$ along the x-axis. Here we select $x = \pi$ as the other end of the string just for convenience. We can pull the string at some point vertically and let it go. That is, we make the string oscillate vertically by plucking it at some point. We can also set the string into motion by giving some initial velocity to each point of its points. We may also combine both of these methods to set the string into motion. Let $u(x, t)$ denote the vertical displacement of the string at any point x and time $t \geq 0$. Then it can be shown [7] that $u(x, t)$ satisfies the following:

Wave Equation:

$$u_{tt} = c^2 u_{xx}, \quad 0 \leq x \leq \pi, \quad t \geq 0. \tag{1}$$

Initial displacement:

$$u(x, 0) = f(x), \quad 0 \leq x \leq \pi. \tag{2}$$

Initial velocity:

$$u_t(x, 0) = g(x). \quad 0 \leq x \leq \pi, \tag{3}$$

Boundary condition:

$$u(0, t) = u(\pi, t) = 0, \quad t \geq 0, \tag{4}$$

where $f(x)$, $g(x)$ denote the initial displacement and initial velocity of the string respectively. Here u_t, u_x denote the first partial derivatives of u with respect to t, x and similar notation is used for second derivatives. The problem is to find u satisfying the above conditions. In 1747, Jean d'Alembert derived the above partial differential equation for u and a solution for the initial-boundary-value problem, see [1], namely

$$u(x, t) = \phi(ct + x) + \phi(ct - x), \tag{5}$$

where ϕ satisfies $\phi(x) - \phi(-x) = f(x)$ and $\phi(x) + \phi(-x) = \frac{1}{c}\int_0^x g(v)dv$, as a sum of two traveling waves one moving to the right and the other moving to the left with the speed c. This describes the motion of the string for each point x and each time t. Implicitly f must be a twice continuously differentiable function.

Leonard Euler
1707–1783

Daniel Bernoulli
1700–1782

In 1748 Leonhard Euler, using geometrical intuition, also arrived at a solution similar to (5), assuming that the initial velocity $g = 0$. He had a big disagreement with d'Alembert about the word "function". In those days a function meant a single analytic formula. It may even be an infinite series representation; but it must be a single formula. For example, $\psi(x) = \begin{cases} x, & x \geq 1 \\ 0, & x < 1 \end{cases}$ is not a function, because it has different formulas on different segments. In particular, the initial displacement of the string may not be represented by a function. In those days a function and graph meant two different things. Also, it was unimaginable to have two functions that agree on an interval but are not equal for other values. Euler claimed that the initial position of the string could be a graph (made up of more than one function) but need not be a function. But d'Alembert took exception to that interpretation. For a detailed discussion on the development of the concept of function see [9]. Euler thought that it was possible to represent some solutions in terms of sines and cosines. So he wrote $u(x,t) = \sum c_k \sin(kx)\cos(kct)$without explicitly stating if the sum is finite or infinite. He meant such a representation to valid only if f is a sum of sines. In fact. The first formal Fourier series [10]

$$\sin x + \frac{\sin(2x)}{2} + \frac{\sin(3x)}{3} + \cdots = \frac{\pi - x}{2}, \quad 0 < x < 2\pi \tag{6}$$

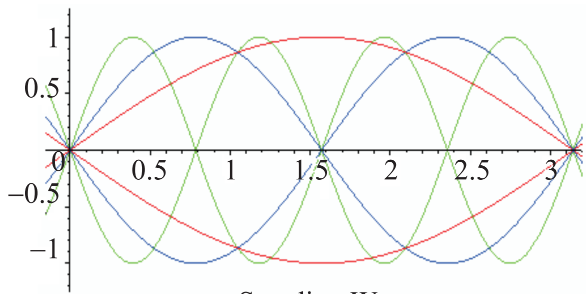
was written by Euler in 1744 and it appears in his Differential Calculus text book in 1755.

In 1755 Daniel Bernoulli the problem approached in an altogether different manner. On the basis his study of discrete systems, he thought that the general solution of a vibrating string can be obtained by composition of fundamental vibrations. That is, his solution to the problem is in terms of standing waves (see the fig. below) with $u(x,0) = f(x),\ u_t(x,0) = 0$. Hence, the general solution is a superposition of the following functions.

$$\sin(x)\ \cos(ct), \sin(2x)\ \cos(2ct), \sin(3x)\cos(3ct), \ldots$$

Note that each one of the above functions satisfies the required conditions of the problem except possibly the initial condition $u(x,0) = f(x)$. So, Bernoulli's solution (separation of variables technique) becomes

$$u(x,t) = \sum_{k=1}^{\infty} c_k \sin(kx)\cos(kct). \tag{7}$$



Standing Waves
"The Harmonics and the Nodes"

Bernoulli claimed that every solution (including both d'Alembert's and Euler's) to the problem of the plucked string is the sum of these standing waves and the sum could be infinite.

Euler's Objections:

(1) Note that if (7) satisfies (2), then

$$f(x) = u(x,0) = \sum_{k=1}^{\infty} c_k \sin(kx), \tag{8}$$

which implies that $f(x)$ must be periodic and (under appropriately stronger type of convergence) differentiable; however the initial position need not be differentiable.

(Under what conditions is the pointwise limit of a sequence of differentiable functions is itself differentiable?)

(2) The right-hand side of (8), being an analytic formula, is a function whereas $f(x)$, being the initial position, need not be a function.

D'Alembert also published a similar attack on Bernoulli's paper. Bernoulli answered these criticisms saying that the values of the series could be made equal to $f(x)$ at infinitely many x by properly choosing c_k (see [7] for related controversies). In those days,

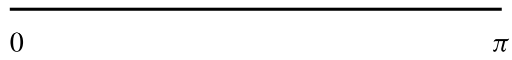
- the thinking was that if two functions agree at infinitely many points, then they must be equal everywhere,
- the nature of infinity was also not clear.

No significant advance was made in the subject until Fourier's experiments on heat conduction.

2. Heat Conduction in Solids

Jean Baptiste Joseph Fourier
1768–1830

In 1804 Joseph Fourier began his studies of heat conduction in solids. One of the first problems he considered was heat conduction in a thin insulated rod made up of some conducting material (see [4]). Let us consider such a rod of length π (for convenience) and place it along x-axis between $x = 0$ and $x = \pi$.



Fourier showed that if $u(x, t)$ denotes the temperature of the rod at the point x and at time t, then $u(x, t)$ satisfies (see [7])

Heat Equation:

$$u_t = k u_{xx}, \quad 0 \le x \le \pi, \quad t \ge 0, \tag{9}$$

where k is a positive constant that depends on the material property of the rod. Suppose that we keep both ends of the rod at zero temperature and we know the initial temperature at every point of the rod. Then the problem is to determine the temperature of the rod at any point $x \in (0, \pi)$ and $t > 0$. That is, the problem is to determine $u(x, t)$ knowing that $u(0, t) = u(\pi, t) = 0$, $t \ge 0$ and $u(x, 0) = f(x)$, $x \in [0, \pi]$. This is again an initial-boundary-value problem just like the vibrating string problem. Using an analysis similar to that of Bernoulli; Fourier observed that any finite sum,

$$u_m(x, t) = \sum_{n=1}^{m} a_n \, e^{-n^2 kt} \, \sin(nx), \quad m \in \mathbf{N}$$

is a solution for (9) satisfying the boundary condition though not necessarily the initial condition. Then Fourier asserted (see [4]) that

$$u(x, t) = \sum_{n=1}^{\infty} a_n \, e^{-n^2 kt} \, \sin(nx) \tag{10}$$

is also a solution to the initial-boundary-value problem, because we can choose the constants a_n appropriately so that (10) satisfies the initial condition $u(x, 0) = f(x)$. That is, he claimed that coefficients a_n could be found so that

$$f(x) = \sum_{n=1}^{\infty} a_n \sin(nx), \qquad 0 \le x \le \pi \tag{11}$$

for any 2π-periodic continuous function f. He also claimed that his method would work for any function given by a formula or for any graph. Fourier, like Euler had calculated the coefficients (now known as *Fourier coefficients*) by a laborious method and found

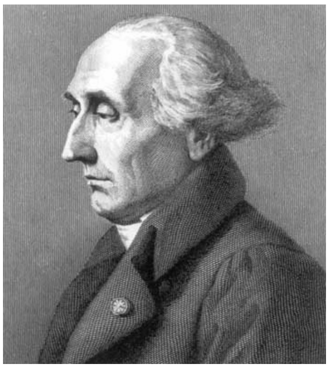
$$a_n = \frac{2}{\pi} \int_0^{\pi} f(x) \, \sin(nx) \, dx. \tag{12}$$

Note that formula (12) follows from (11) if we assume that f is odd and the series can be integrated term by term. Under what conditions is this possible? In those days there was no clear definition of convergence. In 1811, Fourier himself gave one of the first definitions of convergence. A more precise and rigorous definition of convergence was given by Augustin Louis Cauchy later.

Actually, Fourier calculated these coefficients interpreting the integrals as area under a curve. We shall see, as Dirichlet's example would show, that an area interpretation is not always possible. The idea of representing an arbitrary function as a sum of trigonometric functions was rejected by the mathematical community. Some of the problems with the concept of function; others with the nature of convergence (in what sense) etc. Fourier's work contained many examples including discontinuous functions.

In 1807, he submitted his essay "**The Analytic Theory of Heat**" to the French Academy for a prize. This subsequently became one of the most important books in the history of physics. Euler died in 1783 so he was not able to criticize Fourier's theory. But it was criticized by Laplace and Lagrange.

Pierre-Simon de Laplace
1749–1827



Joseph-Louis Lagrange
1736–1813

However, they recognized the importance of his work and awarded him a major prize. Fourier showed that an arbitrary 2π-periodic function could be "expressed" in terms of trigonometric series. Although Fourier attained to somewhat correct views as to the nature of convergence, he did not give any complete general proof.

An actual rigorous proof for convergence was not carried out until Dirichlet took up the subject. In 1822, P. G. Dirichlet came to Paris to study mathematics and became acquainted with Fourier. Fourier encouraged him to work on the convergence problem.

Johann Peter Gustav Lejeune Dirichlet
1805–1859

First of all it was necessary to have a clear definition of "function". So Dirichlet gave the modern definition of a function. He also created the function $f(x) = 1$ if $x \in Q$ and $f(x) = 0$ if x is irrational, which is now known as "Dirichlet's function". Note that this function cannot be graphed. So the interpretation of integral as area under the curve is not possible. Fourier could not have imagined such a function.

In 1829, modifying some of Fourier's work, Dirichlet gave the first proof that the Fourier series of a piecewise continuous function actually converges at each x to the average values of the left-hand and right-hand values of f at x.

Augustin Louis Cauchy
1789–1857

Before we present Dirichlet's Theorem on the convergence of a Fourier series, it is important to mention Cauchy's contribution along this line. As we mentioned earlier, it was Cauchy who saw the importance of rigor in analysis and gave precise definitions of convergence, limit etc. He was the first to use inequalities in the definition of limit and continuity. These rigorous definitions appear in his book published in 1821.

We do not know if Fourier's idea about convergence shaped Cauchy's idea. In 1823 he gave the following definition of integral phrased in current notation:

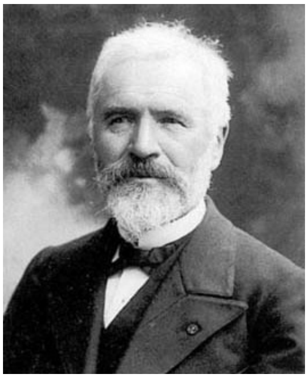
If f is continuous on $[a, b]$ and if $x_0, x_1, \ldots, x_n$ satisfy $a = x_0 < x_1 < \cdots < x_n = b$, then

$$\int_a^b f(x)\,dx = \lim_{n\to\infty} \sum_{k=1}^{n} f(x_{k-1})\,(x_k - x_{k-1}).$$

Cauchy was able to prove that the above limit exists. These were helpful to Dirichlet in proving his convergence theorem.

Dirichlet's Theorem

Let f be a 2π-periodic piecewise C^1-function. Then its Fourier series $\frac{a_0}{2} + \sum_{k=1}^{\infty} [a_k \cos(kx) + b_k \sin(kx)]$ converges to $f(x)$ at every point x where it is continuous and it converges to $\frac{f(x+)+f(x-)}{2}$ at the points x of jump discontinuity. The convergence is uniform on every closed interval that does not contain a discontinuity of f.



Marie Ennemond Camille Jordan 1838–1922

Georg Friedrich Bernhard Riemann 1826–1866

Camille Jordan secured Dirichlet's theorem under weaker hypothesis that the 2π-periodic function f be of bounded variation. Weierstrass theorem on Uniform convergence together with Dirichlet, Jordan theorems show that we can integrate the Fourier series of some nice functions term by term to obtain Fourier coefficients.

To handle functions which do not have graphs, for example, Dirichlet's function, one would need to generalize the notion of integral beyond the intuitive idea of "area under the curve". Bernhard Riemann acquired interest in these topics from his teacher Dirichlet. In 1854, wishing to qualify for a job at Göttingen he wrote a paper on representing a function through a trigonometric series. Here he modified Cauchy's definition of integral (see above) in which he replaced $f(x_{k-1})$ by $f(t_k)$, where $t_k \in [x_{k-1}, x_k]$, required $(x_k - x_{k-1}) \to 0$ as $n \to \infty$ and removed the continuity requirement on f. Then he showed the existence of such an integral and gave an example of an integrable function with infinitely many discontinuities. Now this integral is known as the "Riemann Integral". Of course not every function is Riemann integrable, for example Dirichlet's function is not integrable. Using his theory he gave an example of a function that does not satisfy Dirichlet's or Jordan's condition but has a convergent Fourier series. Riemann also showed the existence of trigonometric series which is not a Fourier series. The difference between a Fourier series and just a trigonometric series is the following:

A series of the form $\frac{a_0}{2} + \sum_{k=1}^{\infty} a_k \cos(kx) + b_k \sin(kx)$ is called a trigonometric series. If the coefficients a_k, b_k follow by $a_k = \frac{1}{\pi}\int_{-\pi}^{\pi} g(x)\cos(kx)\,dx$ and $b_k = \frac{1}{\pi}\int_{-\pi}^{\pi} g(x)\sin(kx)\,dx$ for some integrable g, then the trigonometric series is called a Fourier series. Actually the term "Fourier Series" appears for the first time in Riemann's dissertation.

Karl Theodor Wilhelm Weierstrass 1815–1897

Julius-Wilhelm Richard Dedekind 1831–1916

Many prominent mathematicians like Dirichlet, Riemann, Weierstrass, and Dedekind thought that the Fourier series of a continuous function and perhaps even that of every Riemann integrable would converge pointwise to the function. In fact, Dirichlet thought he would prove this soon.

However, in 1873 Paul du Bois–Reymond constructed an example of a continuous function whose Fourier Series is divergent at a point. This shook up the mathematical community. After Reymond's example many mathematicians started thinking that there might be a continuous function whose Fourier series diverges at every point. Lennart Carleson would prove later that this thinking was incorrect too.

Paul du Bois-Reymond 1831–1889

Georg Ferdinand Ludwig Philip Cantor 1845–1918

Georg Cantor was also interested in Fourier series. He observed that changing a function at a few points does not change its Fourier series, as the coefficients are calculated by evaluating integrals.

Question: How many such point values can be changed and what kind of sets of points can be involved without changing the Fourier series?

This problem led Cantor to his study of infinite sets and cardinal numbers. During this study he also developed a theory of real numbers, and laid a foundation for modern set theory in 1870.

If a series is such that its partial sums are bounded but the series fails to converge, then we can try to apply summability methods, like Cesaro - Summability, to sum it. Basically in summability methods, we average the sequence (in some sense) and ask if the averaged sequence converges.

In 1904 Fejér proved that the Fourier series of every continuous function is $(C, 1)$ - summable to the function. In this new sense, the Fourier series of a continuous function converges uniformly to the function. That is,

Fejér's Theorem:

If f is a continuous 2π-periodic function and

$$S_n(f) = \frac{a_0}{2} + \sum_{k=1}^{n} [a_k \cos(kx) + b_k \sin(kx)]$$

is the nth Fourier partial sum of f, then

$$\sigma_m(f) = \frac{S_1(f) + S_2(f) + \cdots + S_m(f)}{m} \quad \to \quad f$$

uniformly as $m \to \infty$.

Lipot Feje'r 1880–1959

This theorem gave an impetus to summability theory. In 1911, Fejer also gave another example of a continuous function whose Fourier series diverges at a point. We shall see this example later.

Henry Leon Lebesgue 1875–1941

As the Fourier coefficients depend only on the integral it may not be proper to ask whether the Fourier series of f converges to f at every point. Also, if $\{f_n\}_{n=1}^{\infty}$ is a sequence of Riemann integrable functions over $[a,\ b]$ and $f_n \to f$ pointwise on $[a,\ b]$, then it is not necessary that $\lim\limits_{n\to\infty} \int_a^b f_n(x)\, dx = \int_a^b f(x)\, dx$. These problems led to a critical examination of Riemann integration, which led Henri Lebesgue in 1902 , in his dissertation, to define a new kind of integral that is more flexible than Riemann's.

With his new integral, now known as the *Lebesgue integral*, a much larger class than the class of Riemann integrable functions can be integrated. Also, it is much friendlier to the limits. The notions of sets of measure zero and almost everywhere equality of functions now changed the meaning of function even more. In terms of this new idea, Dirichlet's function is zero almost everywhere, and its integral is zero.

Since functions that are equal almost everywhere have the same Fourier coefficients, it is only proper to ask if the Fourier series of a function converges almost everywhere to the function.

Let $L_2[-\pi, \pi)$ denote the set of all real-valued Lebesgue measurable functions defined on $[-\pi, \pi)$ such that $\int_{-\pi}^{\pi} f^2(x)\, dx < \infty$.

Nikolai Nikolaevich Luzin
1883–1950

Andrey Nikolaevich Kolmogorov
1903–1987

In 1913 N. Luzin had assumed that the following result was true, but he was unable to prove this assertion. The problem was therefore given the name of Luzin's conjecture.

Result: The Fourier series of $f \in L_2[-\pi, \pi)$ converges to f almost everywhere.

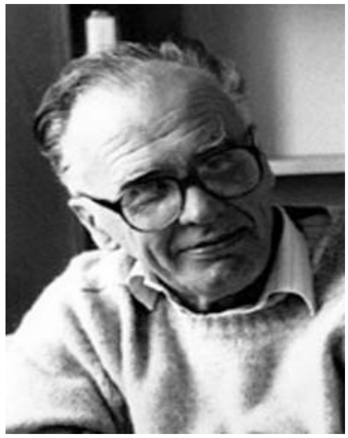
In 1924 A. N. Kolmogorov had asked a different question. Is there is any rearrangement of the orthonormal basis such that the Fourier series of any $f \in L_2[-\pi, \pi)$ converges to f almost everywhere?

In other words, roughly speaking, is it possible to rearrange the basis set $B = \{1, \cos x, \sin x, \cos(2x), \sin(2x), \dots, \cos(nx), \sin(nx), \dots\}$ so that the Fourier series for every $f \in L_2[-\pi, \pi)$ with respect to the rearranged basis set converges to f almost everywhere?

The corresponding problem is still open for general orthonormal basis in abstract L_2 space.

In 1926 Kolmogorov showed that there is a Lebesgue integrable function whose Fourier series diverges almost everywhere.

In 1966 Lennart Carleson [2] proved one of the deepest results in Fourier Analysis (in fact in Analysis?).



Lennart Axel Edvard Carleson
1928 –

He showed Luzin's conjecture was true, meaning that the Fourier series of any $f \in L_2[-\pi, \pi)$ converges almost everywhere to f. This was one of the main results for which L. Carleson was awarded The Abel Prize for 2006 by the Royal Institute of Technology, Stockholm Sweden.

In 1967 R. A. Hunt [6] showed that Carleson's Theorem holds for any $f \in L_p[-\pi, \pi), \ 1 < p < \infty$.

Finally, as we promised let us look at Fejér's example (see [12]) of a continuous function whose Fourier series diverges at a point.

Theorem (Fejér 1911)

There exists a continuous 2π -periodic function whose Fourier series diverges at a point.

Proof. For each $n \in \mathrm{N}$ and $x \in [-\pi, \pi]$ define

$$S_n(x) = \frac{\cos(nx)}{n} + \frac{\cos((n+1)x)}{n-1} + \cdots + \frac{\cos((2n-1)x)}{1} - \frac{\cos((2n+1)x)}{1} - \frac{\cos((2n+2)x)}{2} - \cdots - \frac{\cos((3n)x)}{n} \qquad (13)$$

Then it can be proved (see [10]) that $|S_n(x)| \leq 4\pi + 1$ for all $x \in [-\pi, \pi]$ and $n \in \mathbb{N}$. For each $k \in \mathbb{N}$ let $n_k = 2^{k^2}$ and consider

$$\sum_{k=1}^{\infty} \frac{1}{k^2} \quad S_{n_k}(x). \tag{14}$$

By Weierstrass' M-Test, (14) converges uniformly and hence its limit

$$f(x) = \sum_{k=1}^{\infty} \frac{1}{k^2} \quad S_{n_k}(x) \tag{15}$$

is continuous and 2π -periodic. Note that

$$\begin{aligned} f(x) = 1 \ &\left[\frac{\cos(2x)}{2} + \frac{\cos(3x)}{1} - \frac{\cos(5x)}{1} - \frac{\cos(6x)}{2}\right] \\ &+ \frac{1}{4}\left[\frac{\cos(16x)}{16} + \frac{\cos(17x)}{15} + \cdots + \frac{\cos(31x)}{1}\right. \\ &\left. -\frac{\cos(33x)}{1} - \frac{\cos(34x)}{2} - \cdots - \frac{\cos(48x)}{16}\right] \\ &+ \frac{1}{9}\left[\quad\right] - \cdots \end{aligned}$$

Let $g_i(x)$ be the i-th term in the above series after dropping the parentheses; that is,

$$\begin{aligned} f(x) = \sum_{i=1}^{\infty} g_i(x) = &\frac{\cos(2x)}{2} + \frac{\cos(3x)}{1} - \frac{\cos(5x)}{1} \\ &- \frac{\cos(6x)}{2} + \cdots \end{aligned} \tag{16}$$

This is the Fourier series of f. Now we shall show that the series (16) diverges when $x = 0$ by showing that $\sum_{i=1}^{\infty} g_i(0)$ fails to satisfy Cauchy's convergence criteria.

For a given $n \in \mathbb{N}$ select $N_1 \in \mathbb{N}$ such that $g_{N_1}(0) = \frac{1}{k^2} \frac{1}{n_k}$ for some $k \in \mathbb{N}$. Then

$$g_{N_1+1}(0) = \frac{1}{k^2} \frac{1}{n_k - 1}, \quad g_{N_1+2}(0) = \frac{1}{k^2} \frac{1}{n_k - 2}, \ldots$$
$$\times g_{N_1+n_{k-1}}(0) = \frac{1}{k^2} \frac{1}{1}.$$

Therefore if $\sigma_n = \sum_{i=1}^{n} g_i(0)$, then

$$\begin{aligned} \sigma_{N_1+n_k-1} - \sigma_{N_1-1} &= \frac{1}{k^2}\left(\frac{1}{n_k} + \frac{1}{n_k - 1} + \cdots + \frac{1}{2} + 1\right) \\ &\geq \frac{1}{k^2} \int_1^{n_k} \frac{1}{t}\, dt = \frac{1}{k^2} \ln(n_k) \\ &= \frac{1}{k^2} \ln(2^{k^2}) = \ln(2). \end{aligned}$$

This shows that $\{\sigma_n\}_1^{\infty}$ is not Cauchy and hence $\sum_{i=1}^{\infty} g_i(0)$ diverges. □

Acknowledgements: The author sincerely acknowledges Prof. Bob Burckel for providing important references and discussions. The pictures of the mathematicians were obtained from [13].

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Operator Versions of the Hahn–Banach Theorem

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Abstract. This is an expanded version of the talk given at the 22nd annual meeting of the Ramanujan Mathematical Society on 'Teaching Functional Analysis', June 2007. In this paper starting with the classical result of Goodner–Hasumi–Nachbin and Kelly that characterizes real Banach spaces that admit norm preserving extension of operators taking values in them, we discuss several variations on the theme of norm-preserving operators.

Keywords. Hahn–Banch extensions, Intersection properties of balls, Space of operators

AMS (2000) Subject classification: 46 B 20, 47 L 05

1. Introduction

In this short survey, we will briefly mention without proofs, several 'Operator' versions of the classical Hahn–Banach theorem (HBT) covering some results from the 60's to 06. The idea is that after giving the standard proof of the Hahn–Banach theorem one can interest the students into thinking about what could be some possible ways of 'extending' the classical result. They can be given as an assignment to read and present the proof of some of the versions mentioned here.

We first present the characterization of spaces having the Hahn–Banach extension property. When these ideas are interpreted in terms of intersection properties of balls, variations on this theme, leads to several new classes of Banach spaces. The L^1-preduals (or Lindenstrauss spaces) is one such example.

We also discuss operator versions where operators of a specific class have norm-preserving extensions belonging to the same class. The result of A. Lazar mentioned below is in this category.

In the concluding part we consider a recent generalization [8] of a result of Hopenwasser and Plastiras, [2], dealing with unique extensions of into isometries.

2. Main Results

Let us start by recalling the classical Hahn–Banach Theorem. We will only consider Banach spaces and thus all of our subspaces are closed.

Theorem 1. *Let X be a Banach space and $Y \subset X$ a closed subspace. Let $f\colon Y \to C$ be a continuous linear functional. There exists a continuous linear map $g\colon X \to C$ such that $f = g$ on Y and $\|f\| = \|g\|$.*

Question: Formulate an operator theoretic version?

Let us say that Z is a HB-space if it plays the role of the complex plane in the operator-version.

After some discussion with the students, one will arrive at the following formulation:

Z is a HB-space if for any Banach space X and closed subspace $Y \subset X$, for any bounded linear operator $T\colon Y \to Z$, there exists a bounded linear operator $S\colon X \to Z$ such that $T = S$ on Y and $\|T\| = \|S\|$.

Exercise: Show that $\ell^\infty(n)$ is a HB-space.

Hint: For $1 \leq j \leq n$, consider the continuous functional $e_j \circ T\colon Y \to C$ and apply the HBT. Here e_j is the evaluation functional.

Final answer arrived by mid 70' (Nachbin–Goodner–Hasumi–Kelly–Hustad) (see [4], Chapter 3 and [3]): Z is a HB space if and only if it is isometric to $C(K)$ for a compact extremally disconnected space K (i.e., the closure of any open set is open).

The following intermediate step in the proof of the above theorem has lead to the discovery of several important classes of Banach spaces and variations on this theme continues to play a major role in the geometric theory of Banach spaces.

Seminar idea: Show that a real Banach space Z is a HB space if and only if for any family of pair-wise intersecting closed balls $\{B(z_j, r_j)\}$, $\bigcap B(z_j, r_j) \neq \emptyset$.

An interesting observation here is that two balls $B(z_1, r_1)$, $B(z_2, r_2)$ intersect if and only if $\|z_1 - z_2\| \leq r_1 + r_2$.

Now to show that a space Z satisfying the above condition is a HB space, one first obtains a norm-preserving extension $S\colon Y \oplus \text{span}\{x_0\} \to Z$ and then as in the proof of the classical HBT, Zorn' lemma arguments give the required extension $S\colon X \to Z$. Let us assume that $\|T\| = 1$.

Again as in the proof of the scalar version, one needs to make the operator $S\colon Y \oplus \text{span}\{x_0\} \to Z$ defined by $S(y + \alpha x_0) = T(y) + \alpha z_0$ bounded for an appropriate choice of z_0.

It is easy to see that the balls $\{B(T(x), \|x - x_0\|)\}$ are pair-wise intersecting, so by our hypothesis, a $z_0 \in \bigcap B(T(x), \|x - x_0\|)$ does the job.

Students who have followed the proof of the classical HBT would enjoy how that idea works verbatim here.

In his 1964 AMS Memoir, [7] J. Lindenstrauss among other things studied properties of spaces which for $n \geq 4$ satisfy that any collection of n pair-wise intersecting balls have non-empty intersection. He also showed that if this intersection property holds for $n = 4$, then it will hold for all n.

These are the so-called L^1-predual spaces, i.e., X is such that X^* is isometric to a $L^1(\mu)$-space.

For any compact set K, a theorem of Kakutani (see [4], Chapter 3, Section 9) says that $C(K)$ is a L^1-predual space.

Exercise: Show that $C(K)$ has the above n-intersection property.

In above results dealing with intersection properties, we have taken the scalar field as real numbers. Clearly in the complex plane (which is a complex L^1-predual space), 3 pair-wise intersecting balls can have empty intersection. This difficulty was overcome by O. Hustad, [3], by defining the weak intersection property for a family $\{B(x_i, r_i)\}$ as, for every $x^* \in X^*$, the balls $\{B(x^*(x_i), r_i)\}$ have non-empty intersection in the complex plane. With this notation complex L^1-preduals are those which satisfy, every family of 4 balls with weak intersection property has non-empty intersection [6].

Another variation on the theme of norm-preserving extensions considered by Lindenstrauss and others is to consider extension only to a superspace in which the given space is of co-dimension one. This is like the first step in the proof of the classical Hahn–Banach theorem.

Suppose X is canonically embedded in its bidual X^{**}. Let $X \subset Y \subset X^{**}$ where X is of co-dimension one in Y.

Exercise: For all such Y, $I\colon X \to X$ has a norm-preserving extension to Y if and only if any family of finitely intersecting closed balls in X intersect.

Easy weak*-compactness arguments show that if X is a dual space or more generally the range of a norm one projection in a dual, then this intersection property holds.

It is an open question if this intersection property is equivalent to: $I\colon X \to X$ having a norm-preserving extension to X^{**}? i.e., X is the range of a projection of norm one on X^{**} [1].

Another natural 'operator-version' of the HBT is to consider when operators having certain property have norm preserving extensions satisfying the same property?

The following theorem is due to A. Lazar [5].

Theorem 2. *Let Z be a L^1-predual space such that the dual unit ball of every finite dimensional subspace has only finitely many extreme points. Let $Y \subset X$ and $T\colon Y \to Z$ be a compact operator. Then there exists a norm-preserving compact extension $S\colon X \to Z$.*

Such spaces are called polyhedral spaces.

Exercise: Show that c_0, the space of sequences converging to 0 is such a space. However $Y = \text{span}\left\{\left(\sin\frac{1}{k}\right), \left(\cos\frac{1}{k}\right)\right\} \subset c$ is such that the unit ball of Y^* has infinitely many extreme points.

Let $\mathcal{K}(X, Y)$ and $\mathcal{L}(X, Y)$ denote spaces of compact and bounded linear operators respectively. In the case of a Hilbert space H it is well-known that $\mathcal{K}(H)^{**} = \mathcal{L}(H)$. Under certain assumptions (given below) it turns out that $\mathcal{L}(X, Y)$ is the bidual of the space $\mathcal{K}(X, Y)$. Thus given an operator $\Phi\colon \mathcal{K}(X, Y) \to \mathcal{L}(X, Y)$, $\Phi^{**}\colon \mathcal{L}(X, Y) \to \mathcal{L}(X, Y)^{**}$ is an extension taking values in a larger space.

Our last result due to Rao [8] is another good example of an 'operator'-version of the HBT, also involving uniqueness.

Theorem 3. *Let X, Y be separable reflexive Banach spaces with the metric approximation property. Suppose continuous functionals on $\mathcal{K}(X, Y)$ have unique norm-preserving extensions to $\mathcal{L}(X, Y)$. Let $\Psi_o\colon \mathcal{K}(X, Y) \to \mathcal{L}(X, Y)$ be an into isometry. Then Ψ_0 has a unique extension to an into isometry*

$\Psi\colon \mathcal{L}(X, Y) \to \mathcal{L}(X, Y)$, *if* $\|\Psi_0^*(x \otimes y^*)\| = \|x\|\|y^*\|$ *for all* $x \in X$ *and* $y^* \in Y^*$.

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QIP Short-Term Course on Theory, Numerics and Applications of Differential Equations

10–14 December, 2007

The Department of Mathematics, Indian Institute of Technology (IIT) Guwahati is organizing a Quality Improvement Programme - Short-Term Course (QIP-STC) on Theory, Numerics and Applications of Differential Equations at IIT Guwahati during December 10–14, 2007.

Objectives:

- To provide analytical concepts of differential equations
- To make aware of various techniques to solve different types of problems
- To introduce mathematical software like MATLAB, SCILAB, etc.
- To discuss applications of differential equations to other fields of science & engineering

Boarding and Lodging: Boarding and lodging facilities will be provided for the selected candidates from AICTE approved institutions in the student's hostels of the institute. However, lodging can be arranged in the Institute Guest House on payment (subject to availability).

Eligibility: The course is open to teachers of Engineering Colleges approved by AICTE. No course fee is charged for participants sponsored by AICTE approved institutions.

Participants from Industry and Government organizations are eligible, provided they meet their T.A. and D.A., and pay a course fee of Rs. 4500/- and Rs. 2500/- respectively. The payment is to be made by demand draft drawn on any Nationalized Bank in favor of IIT Guwahati, payable at Guwahati.

Financial Support, Important Dates, Application Format and Other Details May be Obtained From:

`http://www.iitg.ernet.in/natesan/QIP07/index.htm`

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International Conference on Mathematical Sciences (ICMS'07)

28–29 November, 2007

Venue: Equatorial Hotel, Bangi–Putrajaya, Malaysia.

Description: "Integrating Mathematical Sciences within Society".

Focus: Theory and applications of mathematical sciences in engineering, medical, biotechnology, insurance, finance and other related areas.

Important Dates:

Abstract deadline	: July 1, 2007
Conference registration	: August 1, 2007 (early birds)
Full paper deadline	: September 30, 2007

Organizers: Universiti Kebangsaan, Malaysia & Malaysian Mathematical Sciences Society.

For Further Details:

E-mail: seminarppsm@lycos.com

http://pkukmweb.ukm.my/~ppsmfst/icoms/

International Symposium on Recent Advances in Mathematics and its Applications (ISRAMA 2007)

15–17 December, 2007

Venue: Calcutta, India.

Topics: Algebra, Discrete Mathematics & Theoretical Computer Science, Analysis & Topology and their Applications, Geometry and its Applications, Dynamical Systems, Chaos and Fractals, Continuum Mechanics, Plasma Physics, Control Theory and Optimization Theory, Bio-mechanics and Bioinformatics, Applications of Mathematics to Environmental Problems, History and Philosophy of Physical Science, Quantum Information Theory, Relativity and its Applications.

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International Conference on Modeling and Simulation (Emerging Methods towards Frontier Technologies) CITICOMS 2007

27–29 August, 2007

For Further Details Contact:

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Website: http://www.citicoms2007.info/

Fourth National Conference on Mathematical and Computational Models

13–15 December, 2007

Organizers: Department of Mathematics and Computer Applications PSG College of Technology Coimbatore 641 014, India.

General Objectives: People simulate real-world phenomena by creating models which are either mathematical or abstract.

The ability to construct a mathematical model solving complex problems is a craft. Computational models enable the study of complex dynamic worlds because, they themselves are dynamic. Computational models prove their worth in analyzing complex situations. The NCMCM 2007 is the fourth in the series and the main objective of the conference is to provide a timely forum for the exchange and dissemination of new ideas and techniques among the researchers in the various fields of Mathematical and Computational Models.

Topics: Stochastic Models and Optimization techniques Graph Theory Cryptography & Security in Computing Theoretical Computer Science Soft Computing.

Submission of Papers: Authors are requested to submit the soft copy and 3 copies of full papers typed in double line and A4 size paper to the organizing secretary (Max: 10 pages, Font: Times New Roman 10 pts) not later than August 03, 2007. The soft copy should be sent to the E-mail Id: `ncmcm07@mail.psgtech.ac.in`

The hard copies (3 Copies) should be sent to the following address:

Dr. R. Anitha
Organizing Secretary-NCMCM 2007
Department of Mathematics and Computer Applications
PSG College of Technology
Coimbatore 641 004.

Important Dates:

Full manuscript	: August 03, 2007
Intimation of acceptance	: September 08, 2007
Final paper & registration	: September 29, 2007

Registration Fee:

Academic/R & D institutions	: Rs. 1250/-
Industry	: Rs. 2500/-
Research scholars (full time)	: Rs. 750/-

Registration Fee is to be paid by Demand Draft drawn in favor of "NCMCM 2007, PSG College of Technology" payable at Coimbatore.

For each paper to be published in the proceedings, at least one author of the accepted paper has to register for participation.

Accommodation: Accommodation can be arranged in the Guest House/Student Hostels of the college on request. Delegates are however free to make their own arrangements for accommodation in Coimbatore where good hotels are available with affordable tariff rates.

For Further Details:

Contact: Organizing Secretary
Phone: 0422-2572177, 2572477
Fax: 0422-2573833
E-Mail: `ncmcm07@mail.psgtech.ac.in` College
Website: `www.psgtech.edu, www.psgtech.org`

Conference Website:
`http://www.psgtech.edu/conference/ncmcm07/`

First Announcement of a Conference on Representations of Algebras, Groups and Semigroups

December 30, 2007–January 4, 2008

Venue: Ramat Gan and Netanya, Israel

Topics: The representations of groups, semigroups and algebras are closely related. On the one hand, the representations of finite groups and semigroups are identical with the representations of the corresponding group algebras and reduced semigroup algebras, which are finite dimensional algebras. Thus such techniques as quivers and tilting from the theory of finite dimensional algebras are relevant to the representations of groups and semigroups. On the other hand, semigroup representations depend on certain representations of maximal subgroups, and techniques like hooks and cohooks for special bi-serial algebras grew out of group theory. The time is ripe for experts from the three fields to have a joint meeting aimed at finding common ground in their research.

For Further Details Contact:

Stuart Margolis at : `margolis@math.biu.ac.il`
Louis Rowen at : `rowen@math.biu.ac.il`
Malka Schaps at : `mschaps@math.biu.ac.il`

Conference Site:
`http://www.math.biu.ac.il/~margolis/conference.htm`

International Conference Transformation Groups Dedicated to the 70-th Anniversary of Ernest B. Vinberg

17–22 December, 2007

Venue

Independent University of Moscow, Moscow city

Aim: The conference "Transformation Groups" is aimed to review the development of Transformation Group Theory during last decades, to present the most bright recent achievements in this area, and to discuss the perspectives of further research. The conference will be dedicated to the anniversary of Ernest Vinberg, who will become seventy in the summer of 2007. Professor Vinberg is a major expert and active researcher in Lie groups and algebras, discrete and continuous transformation groups, algebraic groups and invariant theory. He has invented numerous methods, proposed many conjectures, and solved a number of difficult and deep problems (both alone and with his collaborators).

The conference is not intended to focus on a narrow set of problems, but rather to present a broad look at recent progress in the field, highlighting new techniques and ideas.

Main Topics of the Conference:

(1) Lie groups and homogeneous spaces in Riemannian, Kählerian, symplectic, and super geometry;
(2) Symmetric spaces;
(3) Discrete subgroups in Lie groups and discrete transformation groups;
(4) Finite and infinite dimensional Lie algebras, conformal and vertex algebras;
(5) Representation theory of Lie groups, Lie algebras, and algebraic groups;
(6) Adjoint and co-adjoint representations;
(7) Structure theory of algebraic groups;
(8) Invariant theory and algebraic transformation groups;
(9) Equivariant embeddings of homogeneous spaces, spherical varieties.

The motivations for the conference are to gather researchers working on transformation groups in various areas of mathematics, in order to extend their ideas and methods to a broader context and to provide an opportunity for a broad discussion and exchange of ideas and experience between mathematicians from various countries and of different generations. Such an exchange would be most useful for those young researchers who make their first steps in mathematics.

During the conference, there will be six working days (Monday, December 17, through Saturday, December 22, 2007) with four one-hour plenary talks (each day) and two half-an-hour sectional talks (on Monday, Wednesday, and Friday). At least three-four sections will be organized. The poster session is also planned.

The conference fee is 150 EURO (except for participants from CIS). It will cover lunches each working day, the conference dinner, coffee-breaks, conference materials, and publication of abstracts.

The registration of participants is available online through the conference web-site. The deadline for registration is September 15, 2007. Due to the limited seating-capacity of the conference rooms, the number of participants is limited to 100 only. If the number of applications will be too large, the organizers may be forced to make a selection among those who will register. The final decision will be taken in September 2007.

Accommodation: The local organizers are ready to book rooms in Moscow hotels for registered participants. Details will appear on our site later. For general information on hotels in Moscow, please consult:

`http://www.moscow-hotels-russia.com`
`http://www.hotels-moscow.ru.`

Abstracts: The registered participants are invited to submit extended abstracts of their talks (1–2 pages, LaTeX format preferable). The abstracts will be published by the opening of the conference in a booklet for the participants. The deadline for abstracts submission is October 15, 2007. We hope on your understanding if time limits do not allow everybody to speak at the conference.

For More Details Visit:

`http://www.mccme.ru/tg2007/`

The 3rd Indian International Conference on Artificial Intelligence (IICAI-07)

17–19 December, 2007

For Further Information Contact:

Bhanu Prasad
IICAI-07 Chair
Department of Computer and Information Sciences
Florida A & M University, Tallahassee
FL 32307, USA
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E-mail: bhanupvsr@gmail.com; http://www.iiconference.org

First Announcement and Call for Papers: The Eighth Asian Symposium on Computer Mathematics (ASCM 2007)

15–17 December, 2007

Venue: National University of Singapore, Singapore.

Description: The Asian Symposia on Computer Mathematics (ASCM) are a series of conferences which offer a forum for participants to present original research, to learn of research progress and new developments, and to exchange ideas and views on doing mathematics using computers. ASCM 2007 will consist of invited talks, regular sessions of contributed papers, and software demonstrations.

Call for Papers: Research papers on all aspects of the interaction between computers and mathematics are solicited for the symposium. Papers should be written in English, in single column, not exceeding 15 pages, and the main text font not smaller than 10 pt. Authors are expected to submit their papers electronically (in postscript, or pdf format).

Deadline for paper submission	: August 31, 2007
Reviewer bidding complete	: September 7, 2007
Paper assignment complete	: September 15, 2007
Deadline for reviewer paper Return (reviews dateline)	: October 21, 2007
Results notification to authors	: October 31, 2007
Conference online registration Dateline	: November 7, 2007
Deadline for camera ready upload	: December 1, 2007
Conference dates	: December 15–17, 2007

For Further Information Visit:

http://www.comp.nus.edu.sg/~ascm2007/.

See submission instructions from the conference

http://www.comp.nus.edu.sg/~ascm2007/A_Instructions.htm

First Joint International Meeting between the AMS and the New Zealand Mathematical Society (NZMS)

12–15 December, 2007

Venue: Wellington, New Zealand.

For Further Details Visit:

http://www.ams.org/amsmtgs/internmtgs.html

Joint AARMS-CRM Workshop on Recent Advances in Functional and Delay Differential Equations

1–5 November, 2007

Venue: Dalhousie University, Halifax, Canada.

Description: Delay differential equations arise in many applications, and in the case of constant delays solutions give rise to semi-flows on function spaces. This workshop will provide a wide perspective on current research and open problems, covering theory, applications and numerical analysis of these equations.

Concentrated Topics: Dissipative Advanced Retarded Equations, Hamiltonian Advanced Retarded Equations Numerical DDEs (Chinese & Italian schools, numerics also in other concentrations), Applications in Mathematical Biology (Mathematical Physiology and Pop Dynamics), Volterra and Integral Equations, State Dependent Delays.

For More Details Visit:

`http://www.crm.math.ca/Dynamics2007/`

National Seminar on Recent Statistical Techniques for Data Analysis and XXIX Annual Conference of Indian Association for the Study of Population (IASP)

26–28 October, 2007

Organizer:

Department of Statistics
Banaras Hindu University
Varanasi 221 005, India.

Scope and Objectives: The seminar will be divided into a number of technical sessions where invited talks and paper presentation will be made. The suggested sessions/topics are:

1. Analysis of Censored and Truncated Data
2. Recent Advances of Data Analysis
3. Sampling Frame as a Determinant of Data
4. Peculiarities and Analysis of Data of Different Disciplines
5. Determinants of Sample Size in a Statistical Enquiry
6. Stochastic Modeling of Demographic Processes.

The above seminar is organized jointly with XXIX Annual Conference of Indian Association for the Study of Population. The theme of this conference is set as "Poverty, Health and Development". As usual it would comprise panel discussions and presentation of invited and contributed research papers and posters on the following five sub-themes:

1. Health, Nutrition and Environment
2. Programmes and Policies of Population and Health
3. Sexual Health and HIV/AIDS
4. Urbanization and Migration
5. Poverty and Development

Submission of Abstract and Full Paper: Authors are invited to submit the abstracts of their talks not more than one side of A4 indicating the theme, main findings and applicability (if any). The abstract should also clearly state the title of the paper and the name(s) of the author(s) with full mailing address including the email address. We encourage you to submit your abstracts to

Prof. K. K. Singh,
Convener & Organizing Secretary
Department of Statistics,
Banaras Hindu University,
Varanasi, India
E-mail: `iasp2007bhu@gmail.com`; `kksingh@bhu.ac.in.`
Phone: (91-542) 2307330, 31 (Office)
(91-542) 2368330 (Res.)
Mobile: +919415256152
Fax: (91-542) 2368174

Last date for receiving abstracts : 31st August 2007
Last date for receiving full papers : 30th September 2007

Registration Fee:

Residents of India: Rs. 500/-
Residents of Foreign Country: US $ 300.

The registration fee will include the conference registration package, lunch and dinner for all three days and accommodation etc. Participants are required to fill-in the registration form and sent the same with payment to Prof. K. K. Singh at the address given above.

Accommodation at BHU/Varanasi: Contact the Organizer

National Seminar on Recent Statistical Techniques for Data Analysis and XXIX Annual Conference of Indian Association for the Study of Population

Registration Form

Name :
Male/Female :
Designation and Affiliation :
Address For Communication :

E-Mail	:
Phone	:
Whether Presenting a Paper	: Yes/No
Title of Paper	:
Author(s)	:
Accommodation	: University/Hotel
Date, Time & Mode of arrival at Varanasi	:
Date, Time & Mode of departure from Varanasi	:
Details of cheque/draft enclosed* Cheque/Draft No.	
Amount	:
Issuing Bank	:

Place:

Date: Signature:

*In favour of Prof. K. K. Singh, Convener & Organizing Secretary

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SRC-IIIDMS

Srinivasa Ramanujan Center for Intensification of Interaction in Interdisciplinary Discrete Mathematical Sciences

Registered: Society No. MYS-S389-2006-07

15 March, 2007

In the world of Mathematics, Srinivasa Ramanujan is well known as a Mathematician of unparalleled originality and exuberance of sophistication who was known for his creativity unknown in the history of Mathematics. Befitting these qualities in him a society called Ramanujan Mathematical Society (RMS) was founded in 1985 to promote Mathematics at all levels.

India is emerging as one of the major centres of research in Discrete Mathematics in recent times, as it is evident from the number of top level research mathematicians working and papers published in this field. Realizing the wide participation of the academicians in Discrete Mathematics, DST as one of the nodal funding agencies is supporting the programmes/spearhead projects/undertakings in the related area. In view of this recently Department of Science and Technology, Government of India has taken initiative to establish National Centres for Advanced Research in Discrete Mathematics (*n-CARDMATH*) in various places in the country. Discrete Mathematics has gained importance in research around the world because of its applications in many disciplines such as **computer science**, physics, chemistry, logic, medicine, biology, psychology etc and it aims to bring together combinatorial mathematics & related areas.

Discrete Mathematics has gained momentum in the recent past and various centres/societies are coming up for the promotion and development of the same. Befitting these criteria recently a society was formed in India called The *Academy of Discrete Mathematics and Applications (ADMA)* to facilitate researchers working in various areas of Discrete Mathematics to come together, promote exchange of information, promote activities conducive to the advancement of knowledge in Discrete Mathematics & its Applications, create awareness about the subject and organize international/national/regional seminar/symposia etc.

"Srinivasa Ramanujan Center for Intensification of Interaction in Interdisciplinary Discrete Mathematical Sciences" (SRC-IIIDMS) is a joint venture of *The University of Mysore* (UoM) and *The Academy of Discrete Mathematics and Applications* (ADMA). SRC-IIIDMS is financially and constitutionally independent managed by a Governing Body consisting of a Governing Board and a Governing Council. This centre will be a hub of intensive academic activities throughout the year, with abundant scope for visiting scientists around the world from all areas of mathematical sciences especially Discrete Mathematicians who might come for academic discussions, interactions, attending seminars and conferences and for delivering series of special lectures for a short period ranging from 3 weeks to 6 weeks.

The objectives of SRC-IIIDMS are scientific and educational, directed towards the advancement of the theory and practice of Discrete Mathematics and Applications to other branches and related fields of human inquiry. Hence main objectives of SRC-IIIDMS are as follows:

(a) To establish the SRC-IIIDMS as an autonomous academic institute based at and having moorings with the University of Mysore.
(b) To manage, administer and maintain the assets of the SRC-IIIDMS.
(c) To seed, promote and further the cause of education, research, interaction and consultancy in the newly emerging fields in 'Discrete Mathematical Sciences'.
(d) To solicit partnership and collaborations with other agencies and institutions, having shared interest and goals.
(e) To liaise with the stakeholder community - the Government, the Industry, the Non-Government Sector and others in fulfilling the mission of SRC-IIIDMS.
(f) To form a collaborative knowledge enterprise based on a cluster approach by forming alliance with other institutions both in India and abroad.
(g) To arrange lecture series, special courses, academic discussions, seminars/symposia/colloquia, workshops/conferences, etc., involving internationally reputed scientists/mathematicians to promote interaction in all interdisciplinary topics in Discrete Mathematical Sciences.
(h) To bring out publications of proceedings of workshops, conferences, etc., held at SRC-IIIDMS.
(i) To do all such things as are necessary to accomplish the above goals of the SRC-IIIDMS.
(j) The academic activities/programmes of the society will be publicized in its own website.

Funds: Since the activity of the centre is envisaged to be both national and international in character the centre welcomes all forms of assistance from Government/Non-Government Agencies and public at large for the promotion of the said objectives and growth of the centre.

Registered Office:
Department of Mathematics,
University of Mysore,
Mysore 570 006,
India.

Governing Board:

1. Professor J. Shashidhara Prasad,
   Vice-Chancellor,
   University of Mysore,
   Mysore.
2. Dr. Anil Kakodkar,
   Chairman, Atomic Energy Commission & Secretary,
   Department of atomic Energy,
   Anushakti Bhavan, Mumbai.
3. Shri. Kaushik Mukherjee,
   Principal Secretary to Govt. Higher Education,
   Education Department,
   Karnataka Govt. Secretariat,
   Bangalore.
4. Dr. K. Kasturirangan,
   Director,
   National Institute of Advanced Studies,
   Indian Institute of Science Campus,
   Bangalore.
5. Professor S. Bhattacharya,
   Director,
   T. I. F. R, Mumbai.
6. Professor P. Balaram,
   Director,
   Indian Institute of Science,
   Bangalore.
7. Professor Sankar K. Pal,
   Director,
   Indian Statistical Institute,
   Kolkata.

Governing Council:

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   Bangalore
2. Professor M. S. Narasimhan, F. R. S,
   T.I.F.R. Centre,
   IISc. Campus, Bangalore.
3. Professor R. K. Shyamasundar,
   Senior Professor, School of Technology & Computer Science, T. I. F. R., Mumbai.
4. Professor Ravi Kulkarni,
   IIT Bombay, Mumbai.
5. Professor C. E. Veni Madhavan,
   Chairman,
   Department of Computer Science and Automation,
   IISc., Bangalore

6. Professor S. B. Rao,
   Former Director ISI, Director (Honorary)
   C. R. Rao Advanced Institute in Mathematics,
   Statistics and Computer Science,
   Hyderabad.
7. Professor R. B. Bapat,
   Head,
   ISI Delhi Centre,
   New Delhi.
8. E. Sampathkumar,
   President, ADMA.

First Announcement for Thirteenth Annual Conference and First International Conference of Gwalior Academy of Mathematical Sciences (GAMS) with Symposium on Mathematical Modeling in Engineering and Biosciences

Organizes:

Gwalior Academy of Mathematical Sciences (GAMS)
http://www.gamsinfo.com

(and)

Anand Engineering College,
Keetham, Agra 282 007 (India)
http://www.sgei.org/AEC.htm

Venue: Anand Engineering College

For Details (Accommodation Details, Registration Fee, Proceedings of the Conference, Important Dates, Post Conference Excursion Tours, etc.)

Contact:

Prof. V. P. Saxena
Anand Engineering College
Keetham, Agra–Delhi Road (N.H. #2)
Agra 282 007, India
Mob.: +91-94251-09044
E-mail: saxena_vp@rediffmail.com
13plus1gams@gmail.com; kamrajp@hotmail.com

National Meet of Research Scholars in Mathematics and Statistics: 2007

(Training Cum Discussion Meeting, Sponsored by the DST, New Delhi)

October 30–November 3, 2007

Important Dates:

Abstract submission : 31st July, 2007
Date of acceptance : 15th August, 2007
Registration date : 31st August, 2007

Call for Papers: In recent years there have been exciting developments in many branches of mathematics and Statistics. These developments require an exposition of newer areas and an interaction within the young researchers to meet the challenges in various fields. In view of this, a **National Meet of Research Scholars in Mathematics and Statistics** is being organized by the Department of Mathematics & Statistics, IIT Kanpur from **October 30–November 3, 2007**.

The aim of this meet is to encourage research scholars/post doctoral fellows working in the frontline research areas of Mathematical Sciences to present their work and to interact with other researchers. This meet will also have expository lectures by some of the prominent mathematicians.

E-mail the abstract of the paper to arlal@iitk.ac.in by **July 31, 2007**.

Fifty research scholars/post doctoral fellows will be selected for presenting their work in the meet and will get travel support.

Topics: *Topics of interest include, but are not limited to*

(1) Algebra and Coding Theory
(2) Graph Theory
(3) Mathematical Modeling in BioSciences
(4) Theoretical Computer Science
(5) Optimization and Game Theory
(6) Statistical Inference
(7) Stochastic Process Modeling
(8) Wavelet Analysis and Fractal Analysis
(9) Numerical schemes & qualitative properties of solutions of differential equations, CFD

Registration: All the selected participants need to register after the acceptance of the abstract for presentation. Registration forms can be downloaded from the Conference site: `www.iitk.ac.in/math/workshop/nationalmeet`

The selected participants should send their registration form along with full paper and a demand draft, in favour of: **"Convener, NMRSMS - 2007, IIT Kanpur"**.

Registration Fee:

Research scholars : Rs. 500/-
Post doctoral fellows : Rs.750/-

The registration fee is refundable if research paper is presented.

Contact:

Dr. A. K. Lal
Convener, NMRSMS - 2007
Department of Mathematics and Statistics
Indian Institute of Technology Kanpur, Kanpur 208 016
E-mail: arlal@iitk.ac.in

For More Information Please Visit our Website:
`www.iitk.ac.in/math/workshop/nationalmeet`

National Conference on Methods and Models in Computing (NCM2C-2007)

13–14 December, 2007

Aim and Scope: The conference aims to provide a forum for academic and research professionals to discuss recent trends in the area of computer science, and include studies on methods and models, and new directions in the related areas.

Topics: Topics of interest include, but are not limited to:

Artificial Intelligence	*Modeling and Simulation*
Computer Networks and Security	*Multimedia and Graphics*
Computational Intelligence	*Optimization*
Computational Complexity	*Programming Languages*
Databases	*Parallel and Distributed Computing*
Data Warehousing and Mining	*Wireless and Mobile Computing*
Embedded Systems	*Software Engineering*

Paper Submission: The submitted papers will be peer-reviewed and carefully evaluated based on originality, technical soundness, significance and clarity. Papers should not exceed 10 pages in length (A4 size, 11 point type, 1.5 spacing) and should be submitted in Microsoft Word. E-mail your paper to us at ncm2c2007@gmail.com. All selected papers will be published in the conference proceedings. For details visit the website: `www.jnu.ac.in/sc_ss/ncm2c2007.php`.

Important Deadlines:

Full paper submission : July 16, 2007
Acceptance notice : September 27, 2007
Camera ready paper submission : October 26, 2007

Please Direct All Correspondence to:

Dr. Sonajharia Minz
School of Computer and Systems Sciences
Jawaharlal Nehru University
New Delhi 110 067
Phone: 26704745, 26717526, 26704767
E-mail: sonaminz@mail.jnu.ac.in, dkl@mail.jnu.ac.in, aditisharan@mail.jun.ac.in

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Hyderabad Symposium in Probability & Statistics (HYDSYMP)

17–19 December, 2007

Organized by:

Department of Mathematics & Statistics
University of Hyderabad
Hyderabad 500 046 India
E-mail: hydsymp@yahoo.com

About the Conference: The first "Hyderabad Symposium in Probability and Statistics" (HYDSYMP) will be held at the University of Hyderabad, Hyderabad, India during 17–19 December, 2007.

Topics to be Covered: Order Statistics, Stochastic Processes, Inference for Stochastic Processes, Nonparametric Density Estimation, Bayesian Inference, Weighted Empirical Processes, Martingale Theory Applications to Inference, Spacings, Linear Models, Income Distribution, Non-parametric

Inference, Bootstrap, Time Series, Applications to Statistical Finance.

Aims & Obiectives: To expose research scholars/teachers to the latest developments in themes of the Conference and to the existing important problems there in so that their research work is directly in the mainstream of the latest advances in the areas of probability and statistics.

Scholarships for Undergraduate Studies in Mathematics NBHM Department of Atomic Energy

As a first step toward supporting undergraduate studies in Mathematics, the Board awards eight scholarships to talented students wishing to pursue undergraduate studies leading to B.Sc. (Honors) degree in mathematics at Punjab University, Chandigarh. The scholarship is of Rs. 1000 each per annum. The maximum duration of the scholarship is three years.

Details of the selection procedure and other relevant information can be obtained from the following address:

Chairperson
Department of Mathematics
Punjab University
Chandigarh 160 014

12th Annual Conference of Vijnana Parishad of India and National Symposium on Applications of Special Functions

25–27 October, 2007

Organizer:

Department of Mathematics and Statistics
Jai Narain Vyas University
Jodhpur 342 001
Rajasthan, India.

Goal of ACVPI & NSASF: The aim of the conference is to bring together Mathematicians and Research Scholars from different parts of the country and expose to them different areas of Mathematics through invited lectures and paper presentations. The three days Annual Conference of Vijnana Parishad of India(ACVPI) will be a platform for enriching the Mathematical flavor and culture of the country by discussing new thoughts and ideas in various fields. The day to day program will be designed to be interactive with the help of the sessions including panel discussions, invited lectures and paper presentations in a wide range of topics of both pure and applied Mathematics. Besides paper presentations and invited talks from experts, a NATIONAL SYMPOSIUM ON APPLICATIONS OF SPECIAL FUNCTIONS(NSASF) will also be organized.

Call for Papers: Participants intending to present papers are invited to submit two copies of the extended abstracts of their papers so as to reach us by August 31, 2007. The abstract must include the title of the paper, author(s) name, their affiliation, brief introduction of the problem, objective, methodology and important outcomes. All abstracts will be reviewed by the academic programme committee and the authors will be informed about their status by September 15, 2007. Conference covers all the areas of pure and applied mathematics and related disciplines. The electronic submission of papers is encouraged.

Proceedings of the Conference: There is a proposal to bring out the proceedings of the conference in a special issue of Jnanabha, a journal published by the Parishad. Therefore the contributors of the papers presented at the conference are requested to submit their full papers by 30th November 2007, if they want to publish them in the proceedings. Only referred and recommended papers will be published.

Registration Fee:

Research scholars:	Rs. 600/-
Other participants:	Rs. 1000/-
Accompanying persons:	Rs. 800/- per person.

The registration form duly filled in along with Registration fee as applicable, by Demand Draft drawn in favour of "Organizing Secretary, ACVPI2007" payable at Jodhpur, must reach the Organizing Secretary by September 30, 2007 so as to enable the organizers to make the proper arrangements. Free boarding and lodging will be provided to all registered participants and their accompanying persons. The participants are requested to make their own travel arrangements and intimate the same to Organizing Secretary.

Contact Persons and their Addresses:

Prof. P. K. Banerji
Chairman, Organizing Committee
Mobile: 09414134446, (O) 0291-2721914

Dr. B. S. Bhadauria
Organizing Secretary
Tel.: 09414136024(M), 0291-2615868(R)

Postal Address:

12th Annual Conference of VPI & NSASF
Department of Mathematics & Statistics
J. N. V. University Jodhpur 342 001(Raj.)

E-mails:

acvpi2007@yahoo.com,
bsbhadauria@rediffmail.com
drbsbhadauria@yahoo.com

All correspondence, including abstracts and Registration Fee etc. should be sent to the Organizing Secretary only.

Registration Form

Name (in BLOCK LETTERS) :

Designation :

Affiliation :

Mailing Address :
Telephone Numbers with STD code :

E-mail :

Title of Talk/ Contributory paper(if any) :

Specialization :

Accompanying person(if any) :

Details of the D.D. No. Dated

Issued by (Bank & Branch) :
Amount :

(DD should be in favour of "Organizing Secretary, ACVPI 2007", payable at Jodhpur)

Date: Signature:

Platinum Jubilee of Indian Statistical Institute, 2006–08

The Indian statistical Institute is organizing, as a part of its Platinum Jubilee celebrations, a series of lectures by distinguished scientists.

The first set of lectures in this series will be delivered by Professor Boris Tsirelson of the Tel Aviv University during 24th to 28th September 2008 at Bangalore, Kolkata and Delhi.

For More Information and Schedule of Talk Please Visit: http://www.isibang.ac.in/~statmath/ or send E-mail to tss@isibang.ac.in

For Further Details:

Prof. T. S. S. R. K. Rao
Convenor, Platinum Jubilee Lecture Series.
Indian Statistical Institute
R. V. College Post
Bangalore, 560059, India
Ph: O: 91-80-28483002 to 6,
H: 91-80-23399019
Fax: O:91-80-28484265
Math-Office: 80-28482724

B. M. Birla Science Centre Fellowships in Italy

B. M. Birla Science Centre is inviting applications for year-long Fellowships, with a possibility for extension, for research in Physics, Mathematics and Computer Science in Italy. PhD in the relevant subject is the requisite qualification. Candidates can forward their CVs by July 30, 2007 to:

Dr. B. G. Sidharth
Director
B. M. Birla Science Centre
Adarsh Nagar
Hyderabad 500 063

National Seminar on Numerical Techniques

3–4 August, 2007

Sponsored by:

Technical Education Quality
Improvement Programme
(TEQIP)

Venue and Organizer:

Department of Mathematics
University College of Engineering
(Autonomous), Osmania University
Hyderabad 500 007

Objectives: The proposed Seminar aims to bring together the researchers working in Mathematical Modelling and are using Numerical Techniques. The Seminar will include presentation of Research Papers and Invited Talks by distinguished speakers from various institutions.

Call for Papers: The organising committee of the Seminar invites research papers for presentation in the Seminar. Participants intending to present papers in the Seminar are requested to submit two copies of the extended Abstracts (Neatly typed on A4 size bond paper) of about 200 words, incorporating the motivation, method of solution and important findgs of their investigations.

Abstracts of research papers along with the completed Registration form and prescribed registration fee in the form D. D. in favour of "Head, Department of Mathematics, UCE(A), Osmania University", payable at SBH, O.U, Hyderabad, 500 007 and should be sent to:

Prof. D. Rama Murthy
Head, Department of Mathematics
University College of Engineering, O. U., Hyderabad 500 007
Ph. No. 040-27682208
Mobile: 9849665202
E-mail: drmurthy2k1@Yahoo.co.in

Last date for the Submission of Abstracts and Registration forms: 20-07-2007
Registration Fee: Rs. 200/-

National Seminar on Numerical Techniques

Application Form for Registration:

1) Name:
2) Designation and address for correspondence:
3) I expect to attend the Seminar: Yes/No
4) I expect to present a paper at the Seminar:
   Yes/No
   If Yes, the title of the paper
5) Registration fee by D.D.:
   Draft No.:
   Date:
   Name of the Bank:
   Rs.
6) E-mail and Phone No.

Date: Signature:

Government of India, National Board for Higher Mathematics, Department of Atomic Energy

Anushakti Bhavan, C. S. M. Marg, Mumbai 400 001

E-mail: msnbhm@dae.gov.in Website: www.nbhm.dae.gov.in

Scholarships for Pursuing Post Graduate Studies (M.A./M.Sc.) in Mathematics for the Academic Year 2007–08

The National Board for Higher Mathematics (NBHM) invites applications for the grant of scholarships to students for pursuing studies for M.A./M.Sc. degree in mathematics.

Eligibility: Applicants must be motivated B.A./B.Sc. first class degree holders, or students, who have appeared for B.A./B.Sc. final year examination and expect a bachelors degree with first class, or B.Sc. (honors) degree holders with at least second class, or students, who have appeared for B.Sc. (honors) final year examination and expect a B.Sc. (honors) degree with at least second class. Students who have completed three years of an integrated M.Sc. course with cumulative grades equivalent to first class are also eligible to apply.

Applicants should be below the age of **23 years** as on **January 1, 2007**. Exceptional cases, however, may be considered on merit.

The Scholarship: Successful candidates will be eligible to receive a scholarship of Rs. 4,000/- (Rs. four thousand only) per month, during their two-year (one-year if the student is granted the scholarship during the second year) M.A./M.Sc. programme. The scholarships are sanctioned for one year at a time and are renewable at the end of the year, subject to satisfactory progress.

To avail of the scholarship the students have to be enrolled in an appropriate institution for an M.A./M.Sc. degree in Mathematics. The scholarship will be paid through the institution they join.

Selection Procedure: Selection will be made on the basis of a written test followed by interview of short-listed candidates. The written test will be held on **Saturday, September 22, 2007**. The questions will be primarily in the areas of Algebra, Analysis and Geometry. The test will be for two and half hours and involve questions with short answers. (Please visit `http://www.nbhm.dae.gov.in` for question papers for some earlier years.)

The written test will be conducted at the following centres:

Zone 1: Chandigarh, New Delhi
Zone 2: Allahabad, Indore, Jabalpur
Zone 3: Mumbai, Goa, Pune, Vallabh Vidyanagar
Zone 4: Kolkata, Bhubaneswar, Guwahati, Ranchi, Shilong
Zone 5: Chennai, Bangalore, Cochin, Hyderabad

How to Apply: Applications on plain paper should be made in the format given at the end of the advertisement. They should be sent in duplicate along with a recent passport size photograph attached to each copy and a self-addressed envelope, affixed with a Rs. 5/- postage stamp, to the appropriate person for the Zone in which the candidate wishes to appear for the written test. The envelope containing the application should be super-scribed "NBHM M.A./M.Sc. Scholarships". Addresses of persons (zonal coordinators) to whom the applications should be sent, are given below.

Two centres where the candidate may like to appear for the written test must be clearly indicated giving the order of preference. While it is not guaranteed that a centre of a candidate.s choice will be allotted, every effort will be made to do so. NBHM reserves the right to allot the centre closest to the indicated alternatives.

Address for sending completed applications:

Zone 1:
Prof. R. J. Hans Gill,
Department of Mathematics,
Panjab University,
Hans Raj Gupta Hall,
Chandigarh 160 014.
E-mail: `hansgill@pu.ac.in`

Zone 2:
Prof. Satya Deo Tripathi,
Harish-Chandra Research Institute,
Chhatnag Road, Jhusi,
Allahabad 211 019.
E-mail: `vcsdeo@yahoo.com`

Zone 3:	Prof. S. G. Dani, School of Mathematics, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, **Mumbai 400 005.**	E-mail: dani@math.tifr.res.in
Zone 4:	Prof. S. C. Bagchi, Stat-Math Unit, Indian Statistical Institute, 203 B.T. Road, **Kolkata 700 108.**	E-mail: somesh@isical.ac.in
Zone 5:	Prof. S. Kesavan, Institute of Mathematical Sciences, C.I.T. Campus, Taramani, **Chennai 600 113.**	E-mail: kesh@imsc.res.in

Deadline: The last date for the receipt of completed applications is **Monday, July 30, 2007**.

A communication calling the applicant for the test (hall ticket), together with allotment of center will be sent so as to reach the candidate by **August 31, 2007. In the event of an applicant not receiving a communication regarding the test by the due date, the eligible applicant shall contact the person (zonal coordinator), to whom the application was sent, to find out the status and the appropriate remedial measures**.

A hall-ticket sent by a zonal coordinator is normally necessary to appear for the test. In exceptional cases, eligible candidates may be admitted to the test, *at the discretion* of the centre-in-charge at the appropriate centre. For this purpose, the applicant must contact the centre-in-charge suggested by the appropriate zonal coordinator. Information about test centres and persons-in-charge may be obtained from the zonal coordinator, NBHM website or by contacting NBHM office (address at the top).

Important Dates:

July 30, 2007	:	Last date of receiving application.
August 31, 2007	:	The applicant should contact the *zonal coordinator* to whom the application was sent, if he/she does not receive a communication about the test (or hall-ticket) by this date.
September 14, 2007	:	The applicant must *contact the centre* suggested by the zonal coordinator if the applicant does not receive a hall ticket by this date.
September 22, 2007	:	Date of Written Test.

Proforma of Application

National Board for Higher Mathematics
Application for Scholarship in Mathematics

Paste a photograph here

(1) Name (in BLOCK LETTERS); (2) Male/Female; (3a) Address for correspondence (in BLOCK LETTERS with PIN code); (3b) E-mail id. (3c) Phone number, Mobile number, Fax Number (4a) Date of birth (4b) Place of birth (4c) Nationality; (5) Details of bachelor's degree examination passed/appeared for (enclose one set of attested copies of mark sheets) in the following format. (If certain details are not known, leave the space blank.);

College/Institution	University	Examination Passed/ appeared for	Year of Passing	Division/Class and % of marks Obtained	% of marks in Mathematics

(6) other relevant information in support of your candidature including awards or scholarships; (7) whether you applied for NBHM Scholarships in the past. If yes, give year(s) of application, whether called for written test/interview and the outcome and (8) choice of two centres in order of preference, from the list given in the Advertisement.

Place:

Date: (Signature of the applicant)

Government of India
Ministry of Science and Technology
Department of Science and Technology

Division (BOYSCAST Programme)
Technology Bhavan, New Mehrauli Road
New Delhi 110 016

BOYSCAST Fellowship for the Year 2007–08: The Better Opportunities for Young Scientists in Chosen Areas of Science & Technology (BOYSCAST) programme of the Department of Science & Technology (DST) provides opportunities to the young Indian scientists/technologists to visit institutions abroad, interact with scientists/technologists there, get trained in latest research techniques and conduct R&D in specially chosen frontline areas of science & technology. Applications are invited from Indian Nationals for the award of fellowships under the BOYSCAST programme for conducting advanced research and undergoing training in advanced research techniques in overseas research laboratories/institutes, in chosen frontline areas of science & technology for the period of three to twelve months. The areas are given below:

Young Indian scientists/technologists are eligible to apply. The details such as Academic Qualifications, Guidelines Governing the Programme, Procedure for Application, Formats, etc. may be obtained from:

`http://serc-dst.org/boycast2007-8.htm`

Deadline is **31st July, 2007**

The readers may download the Mathematics Newsletter from the RMS website at
`www.ramanujanmathsociety.org`