Design Resources Server
(www.iasri.res.in/design)

Design Resources Server is in fact a Design of Experiments Server created with an objective to disseminate research. The server is supposed to help the advancement in theoretical, computational, and statistical aspects of Design of Experiments among the academic and industrial practitioners. The site makes available design theory and the actual protocol of the design through links.

One of the important features of the server is the "Ask a Question" section which provides answers to any queries or uncertainties in the designing process. The ultimate objective of this server is to provide a service to the design community. Presently, this is being achieved through the "Ask a Question" section.

Electronics, besides design of experiments and advances in data analytical techniques are also available on the server. Exposition to software packages used in statistical analysis of data followed by statistical principles on various topics and their real-life applications are also available.

It is expected that the material provided in this server would help the practitioners in general and agricultural scientists in particular in improving the quality of research in their respective sciences and making their research globally competitive.

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DESIGN RESOURCES SERVER has been designed and developed under the ICAR National Fellow and the ICAR National Professor Research Schemes being run at IASRI, New Delhi with the active support of Mrs. Alka Arora and Dr. A. Dhandapani. It is hosted at www.iasri.res.in/design and is being maintained by Shri Rakesh Saini and Shri Subhash Chand. The server is dynamic in nature and new additions are being posted on it from time to time to strengthen it further and to broaden the horizon of its reach. The authors are grateful to the Education Division of ICAR (www.icar.org.in) for supporting the two schemes, which has ultimately resulted into the creation of this server that targets to help improve the quality of agricultural research and make it globally competitive through the adoption of modern, sophisticated and appropriate designs and proper analysis of data so as to draw meaningful and valid conclusions. The authors would also like to express their heartfelt thanks to the Director, Indian Agricultural Statistics Research Institute, New Delhi for providing necessary facilities and hosting this server on the Institute home page. Many scientists, technical staff, research associates, and others have helped in the development and maintenance of this server and the authors are pleased to acknowledge their help and support.
About Design Resources Server ~

- hosted at www.iasri.res.in/design/ is an e-learning and e-advisory resource for the experimenters
- a platform to popularize and disseminate research and also to further strengthen research in newer emerging areas in design of experiments among peers over the globe in general and among the agricultural scientists in particular so as to meet the emerging challenges of agricultural research
- spread advances in theoretical, computational and statistical aspects of design of experiments among the mathematicians and statisticians in academia and among the practicing statisticians involved in advisory and consultancy services
- help experimenters in agricultural sciences, biological sciences, animal sciences, social sciences and industry in planning, designing and analyzing experiments by providing online an appropriate, efficient design and its randomized layout, which can be used by the experimenters straightaway for experimentation
- provide support in the analysis of data generated by giving steps of analysis of actual experiments conducted by scientists at various places using various statistical software packages to enable the scientists analyze the data easily and also to understand and appreciate the advantages gained by the design adopted and the subsequent analysis carried out. The scientists would have to use software from their own resources to take advantage of the facilities available at Design Resources Server
- online analysis of data available for few experimental settings
- a virtual mobile library on design of experiments
- dynamic in nature and new additions would be posted on it from time to time
- aims to expand its coverage to other statistical methods
- would help experimenters in general and agricultural scientists in particular in improving the quality of research in their respective sciences and making their research globally competitive
- welcomes anyone around the globe to join and add information to the site to strengthen it further

The home page of the server is
The material on the server has been structured into the following four major groups:

**Useful for Experimenters**
- e-learning
- online generation of randomized layout of basic designs, resolvable block designs and augmented designs
- online analysis of data
- steps of analysis of data using various statistical software packages
- online analysis of data generated from augmented designs

**Useful for Statisticians**
- literature and catalogues of binary balanced block designs
- designs for making test treatments-control treatment comparisons
- designs for bio-assays
- supersaturated designs
- experiments with mixtures
- online generation of Hadamard matrices
- Mutually orthogonal Latin squares and orthogonal arrays

**Other Useful Links**
- discussion board
- ask a question
- who-is-where
- important links

**Site Information**
- feedback
- how to quote design resources server
- copyright, disclaimer
- contact us
- site map

The two major components of the server are (i) Useful for Experimenters and (ii) Useful for Statisticians. The scientists, however, can use either of the two components depending upon their choices.
This link has been designed essentially to meet the requirements of the experimenters whose prime interest is in designing the experiment and then subsequently analyzing the data generated so as to draw meaningful inferences. To meet this end, this link contains the following sub-links:

**2.1 E-Learning**
This is an important link that provides useful and important reading material on use of some statistical software packages, designing experiments, statistical analysis of data and other useful topics in statistics in the form of two electronic books viz.
1. Design and Analysis of Agricultural Experiments  
   [www.iasri.res.in/design/Electronic-Book/index.htm](http://www.iasri.res.in/design/Electronic-Book/index.htm)
2. Advances in Data Analytical Techniques  
   [www.iasri.res.in/design/ebook/EBADAT/index.htm](http://www.iasri.res.in/design/ebook/EBADAT/index.htm)

The first pages of these books are shown below:

![Book Pages]

The coverage is very wide and almost all the aspects of designing an experiment and analysis of data are covered in these electronic books. The chapters are decorated with solved examples giving the steps of analysis. The users can have online access to these electronic books. This provides good theoretical support and also reading material to the users.

**2.2 Online Design Generation-I**
This link is very useful for experimenters because it helps in generation of randomized layout of the following designs:
**Basic Designs:** Generates of randomized layout of completely randomized designs and randomized complete block designs both for single factor and multifactor experiments and Latin square designs for single factor experiments. The field book can be created as a .csv file or a text file. This is available at

www.iasri.res.in/design/Basic_Designs/generate_designs.htm.

**Augmented Designs:** A large number of germplasm evaluation trials are conducted using augmented designs. The experimenters generally compromise with the randomization of treatments in the design. Further, experimenters also need to know the optimum replication number of controls in each block so as to maximize the efficiency per observation. Online software for generation of randomized layout of an augmented randomized complete block design for given number of test treatments, control treatments and number of blocks with given block sizes, not necessarily equal is developed and is available at

www.iasri.res.in/design/Augmented_Designs/home.htm.

The design can be generated with optimum replication of control treatments in each block so as to maximize efficiency per observation.

**Resolvable Block Designs:** Resolvable block designs is an important class of incomplete block designs wherein the blocks can be formed together into sets with the blocks within each set constituting a complete replication. In the class of resolvable block designs, square lattice designs are very popular among experimenters. One can generate square lattice designs with three replications using

www.iasri.res.in/WebHadamard/square_lattice.htm.

Another important class of resolvable block designs is the alpha designs. These designs are available when the number of treatments is a composite number. Literature on alpha designs is available at

www.iasri.res.in/design/Alpha/Home.htm.

This link also provides randomized layout of alpha designs for $6^d v (= sk$, the number of treatments) $d'' 150$, $2 d'' r$ (number of replications) $d'' 5$, $3d'' k$ (block size) $d'' 10$ and $2 d'' s d'' 15$ along with the lower bounds to A- and D- efficiencies of the designs.

The screen shots for generation of randomized layout of basic designs, augmented designs, square lattice designs and alpha designs are
2.3 Online Analysis of Data
This link together with Analysis of Data forms the backbone of the Design Resources Server. This particular link targets at providing online analysis of data generated to the experimenter. At present an experimenter can perform online analysis of data generated from augmented randomized incomplete block designs. This is available at www.iasri.res.in/spadweb/index.htm.

2.4 Analysis of Data
This link becomes the most important link of the server because it targets at providing steps of analysis of data generated from designed experiments using several statistical packages like SAS, SPSS, GenStat, MINITAB, SYSTAT, SPAD, SPFE, SPAR 2.0, MS-Excel, etc. Some real life
examples of experiments are given and the questions to be answered are listed. Steps for preparation of data files, the commands and macros to be used for analysis of data and the treatment contrasts to be used for answering specific questions, etc. are given, which the user can use without any difficulty. The data files and result files can also be downloaded. This is available at www.iasri.res.in/design/Analysis of data/Analysis of Data.html.

The following analysis can be performed using this link:

- Analysis of data generated from randomized complete block design; incomplete block design; resolvable incomplete block design; Latin Square design; factorial experiments both without and with confounding; steps of analysis of Augmented Design using SAS, SPSS and SPAD
- Response surface design using SAS and SPSS; Analysis of mixture experiments
- SAS code given for analysis of Groups of Experiments conducted in different environments (locations or season / year), each experiment conducted as a complete block or an incomplete block design. Using this code, one can analyze the data for each of the environments separately, test the homogeneity of error variances using Bartlett’s $\chi^2$-test, perform combined analysis of data considering both environment effects as fixed and environment effects as random (both through PROC GLM and PROC MIXED) and prepare site regression or GGE biplots
- SAS Macro for performing diagnostics (normality and homogeneity of errors) in experimental data generated through randomized complete block designs and then applying remedial measures such as Box-Cox transformation and applying the non-parametric tests if the errors remain non-normal and / or heterogeneous even after transformation
- SAS codes are also available for obtaining descriptive statistics, generating discrete frequency distribution, grouped frequency distribution, histogram, testing the normality of a given variable (overall groups or for each of the groups separately)
- correlation and regression using SAS and SPSS
- Tests of significance based on Student’s $t$-distribution using SAS, SPSS and MS-EXCEL
- SAS code for performing principal component analysis and analysis of covariance

The screen shots for analysis of data appears like
This link is useful for researchers engaged in conducting research in design of experiments. This can also be used in the class room teaching in Statistics. The material on this link is divided into the following sub-links:

3.1 Block Designs
This link provides some theoretical considerations of balanced incomplete block (BIB) designs, binary variance balanced block (BBB) designs with 2 and 3 distinct block sizes, partially balanced incomplete block (PBIB) designs, designs for test treatments-control treatment(s) comparisons, etc. for research statisticians. The link also gives a catalogue of designs and a bibliography on the subject for use of researchers. At present the following material is available on this link:

- General method of construction of BBB designs; general methods of construction of block designs for making test treatments – control treatment(s) comparisons; bibliography
- Catalogue of BIB designs for number of replications \( r \leq 30 \) for symmetric BIB designs and \( r \leq 20 \) for asymmetric BIB designs
- Catalogue of BBB designs with 2 and 3 distinct block sizes for number of replications \( r \leq 30 \). The catalogue also gives the resolvability status of the designs along with the efficiency factor of the designs
- 6574 block designs for making all possible pair wise treatment comparisons for \( v \leq 35 \) (number of treatments), \( b \leq 64 \) (number of blocks), \( k \leq 34 \) (block size)

Some screen shots on block designs are given below:
3.2 Designs for Bioassays
Designs for biological assays help in estimation of relative potency of the test preparation with respect to the standard one. The material uploaded includes contrasts of interest in parallel line assays and slope ratio assays. This link provides some theoretical considerations of designs for bioassays along with a catalogue of designs and a bibliography on the subject for use of researchers. Literature on bioassays is available at

www.iasri.res.in/design/BioAssays/bioassay.html.

Some screen shots of this link are displayed below:

![Screen shots of Designs for Bio-assays](image)

3.3 Designs for Factorial Experiments
Factorial experiments are most popular among agricultural scientists. To begin with material on supersaturated designs is available on this link. Supersaturated designs are fractional factorial designs in which the degrees of freedom for all its main effects and the intercept term exceed the total number of distinct factor level combinations of the design. These designs are useful when the experimenter is interested in identifying the active factors through the experiment and experimental resources are scarce. Definition of supersaturated designs, experimental situations in which supersaturated designs are useful, efficiency criteria for evaluation of supersaturated designs, catalogue of supersaturated designs for 2-level factorial experiments and asymmetrical factorial experiments and bibliography on supersaturated designs has been uploaded on the Server. The complete details of the runs can be obtained by clicking on the required design in the catalogue.

www.iasri.res.in/design/Supersaturated_Design/Supersaturated.html.
Some screen shots on supersaturated designs are

3.4 Experiments with Mixtures

Experiments with mixtures are quite useful for the experiments where a fixed quantity of inputs (may be same dose of fertilizer, same quantity of irrigation water or same dose of insecticide or pesticide etc.) are applied as a combination of two or more ingredients. In these experiments the response is a function of the proportion of the ingredients in the mixture rather than the actual amount of the mixture. A new page has been initiated on “Experiments with Mixtures” on Design Resources Server. A bibliography of Experiments with mixtures and online generation of Simplex Centroid designs are available on this page [http://www.iasri.res.in/mixture/mixtures.aspx](http://www.iasri.res.in/mixture/mixtures.aspx). Some screen shots on Experiments with Mixtures are:

3.5 Online Design Generation- II

This link is helpful in generation of the following:

**Hadamard Matrix**

Hadamard matrices have a tremendous potential for applications in many fields particularly in fractional factorial plans, supersaturated designs, variance estimation from large scale complex survey data, generation of incomplete block designs, coding theory, etc. One can generate Hadamard matrices for all permissible orders up to 1000 except 668, 716, 876 and 892 using the URL
Design Resources Server

www.iasri.res.in/WebHadamard/WebHadamard.htm. Methods implemented produce Hadamard matrices in semi-normalized or normalized form. “None” option is also available. Hadamard matrix can be generated in (0,1); (+1,-1); or (+,-) form. The method of generation of Hadamard matrix is also given. The screen shots for generation of Hadamard matrices are

**Mutually Orthogonal Latin Squares and Orthogonal Arrays**

Using this link one can generate complete set of mutually orthogonal Latin squares of order s, s being a prime or prime power less than 1000 have been linked under online design generation of Design Resources Server. Using this link one can also generate an Orthogonal Array with parameters (s**(s<x1), s^2, s, 2) by choosing the output option as Orthogonal Arrays. 

www.iasri.res.in/WebHadamard/mols.htm. Some screen shots on MOLS and orthogobnal arrays are

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**3.6 Workshop Proceedings**

Proceedings of 3 dissemination workshops are available for the stakeholders

1. Design and Analysis of On-Station and On-Farm Agricultural Experiments
2. Design and Analysis of Bioassays
3. Outliers in Designed Experiments
The purpose of this component is to develop a network of scientists in general and a network of statisticians in particular around the globe so that interesting and useful information can be shared among the peers. It also attempts to provide a sort of advisory also to the scientists. Some other useful but important links available around the globe are also provided.

4.1 Discussion Board
The purpose of discussion board is to create a network of scientists and also to provide a platform for sharing any useful piece of research or idea with any other scientists over the globe. The user can use this board for learning and disseminating information after registering on the discussion board. The information can be viewed by anybody over the globe. If there are some queries or some researchable issues then other peers can also respond to these queries.

4.2 Ask a Question
The ultimate objective of this server is to provide e-learning and e-advisory services. At present this is being achieved through the link “Ask a Question”. Once a user submits a question, a mail is automatically generated for Dr. Rajender Parsad, Dr. V.K. Gupta and Mrs. Alka Arora who answer the question on receiving the mail.
4.3 Who-is-where
Addresses of important contributors in Design of Experiments including their E-mail addresses have been linked to Design Resources Server. The list includes experts from USA, Canada, Australia, UK, China, Japan, Mexico, New Zealand, Oman, Syria, Taiwan, Vietnam and India. This information is useful for all the researchers in Design of Experiments in establishing linkages with their counterparts over the globe.

4.4 Important Links
This gives links to other important sites that provide useful material on statistical learning in general and Design of Experiments in particular.
This link provides information about the site on the following aspects (i) Feedback from stakeholders, (ii) How to Quote Design Resources Server, (iii) Copyright, (iv) Disclaimer, (v) Contact us, and (vi) Sitemap. A brief summary of feedback is given in the sequel.

5.1 Feedback / Comments
The feedback / comments received from the users visiting the site have been put on the server so that every user can benefit from the experience of other users. More importantly, the feedback helps in improving the contents of the site and their presentation too.

5.2 How to quote design resources server
To Quote Design Resources Server, use:

**Design Resources Server. Indian Agricultural Statistics Research Institute (ICAR), New Delhi 110 012, India.** www.iasri.res.in/design (accessed last on <date>).

If referring to a particular page, then the site may be quoted as

Authors’ name in ‘Contact Us’ list on that page. Title of page: Design Resources Server. **Indian Agricultural Statistics Research Institute (ICAR), New Delhi 110 012, India.** www.iasri.res.in/design (accessed last on <date>).

For example, page on alpha designs may be cited as

Parsad, R., Gupta, V.K. and Dhandapani, A. Alpha Designs: Design Resources Server. **Indian Agricultural Statistics Research Institute (ICAR), New Delhi 110 012, India.** www.iasri.res.in/design (accessed last on 06.03.2009).

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Every effort is made to keep the website up-to-date and running smoothly. However, “IASRI” takes no responsibility for and will not be liable for the website being temporarily unavailable due to technical issues beyond our control.

5.5 Site Map
This link gives a map of the various links available on the server. A user can access any of the links through this map also. A snap shot of the site map is given below:
SOME INFORMATION ON THE USAGE OF THE SERVER

- Design Resources Server is a copyright of IASRI (ICAR). The Server was registered under Google analytics on May 26, 2008. For the period May 26- March 21, 2009, Google Analytics gave 4841 page views, with 3893 unique page views and usage through 511 cities in 79 countries spread over 6 continents.

- External links of the server are also available at:

- The server has been cited at:
     for lecture presentation on Unitary operators.


     Server is also linked at

- ICARDA Intranet: Biometric Services
  CG Online learning resources- http://learning.cgiar.org/moodle/Experimental Designs and Data Analysis
FUTURE DIRECTIONS

The design resources server created and being strengthened at IASRI aims to culminate into an expert system on Design of Experiments. To achieve this end, the materials available on various links need to be strengthened dynamically. Besides this, the following additions need to be made to the server in the near future:

- Online generation of
  - Balanced Incomplete Block designs, Binary Balanced Block designs and Partially Balanced Incomplete Block designs
  - Block designs with nested factors
  - Designs for crop sequence experiments
  - Efficient designs for correlated error Structures
  - Online generation of row-column designs
  - Designs for factorial experiments; fractional factorial plans
- Designs for microarray experiments
- Designs for computer experiments
- Designs for fitting response surfaces; Designs for experiments with mixtures
- Split and Strip plot designs
- Field book of all the designs generated
- Labels generation for preparing seed packets
- Online analysis of data
- Steps for analyzing data using GENSTAT, R, SYSTAT, etc.
**Design Resources Server** has been developed to popularize and disseminate research in design of experiments among experimenters in agricultural sciences, biological sciences, animal sciences, social sciences and industry in planning and designing their experiments for making precise and valid inferences on the problems of their interest. It also provides support for analysis of data generated so as to meet the objectives of the study. This server aims at providing a platform to the researchers in design of experiments for disseminating research and also strengthening research in newer emerging areas so as to meet the challenges of agricultural research. This server attempts to spread advances in theoretical, computational and statistical aspects of design of experiments among the mathematicians and statisticians in academia and among the statisticians involved in advisory and consultancy services.

The Design Resources Server contains a lot of useful information for Experimenters / Statisticians. The material available on the server has been partitioned into four main components:

- **Useful for Experimenters:** Electronic Books, online generation of randomized layout of designs, online analysis of data, analysis of data using various software
- **Useful for Statisticians:** Literature and catalogues of binary balanced block designs, designs for making test treatments-control treatment comparisons, supersaturated designs, online generation of Hadamard matrices, mutually orthogonal Latin squares (MOLS) and orthogonal arrays
- **Other Useful Links:** Discussion board, ask a question, who-is-where, important links
- **Site Information:** Feedback, how to quote design resources server, copyright, disclaimer, contact us and site map

The Design Resources Server is a virtual mobile library on design of experiments in particular and Statistics in general. It provides useful information both for active researchers in Statistics as well as stakeholders like scientists in National Agricultural Research System and others all over the globe. The server is dynamic in nature with new additions being posted on it from time to time. Other scientists around the globe are also welcome to join and add information to the site to strengthen it further.

The server is hosted at the home page of Indian Agricultural Statistics Research Institute, New Delhi and can be reached at www.iasri.res.in/design.

For any critical comments / suggestions that help in improving the contents and the presentation so as to make the server more meaningful to the experimenters, please write to

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