

## GAMS Courses 2011

### – B&A: Modeling and Optimization with GAMS –

#### Summary

In 2011 we offer a basic (B111) and advanced (A111) course:

**B111** 07.-09.11.2011 (see page 2)

**A111** 10./11.11.2011 (see page 6)

**Location:** Hotel Speeter, Weisenheim am Berg, Germany, only one hour away from Frankfurt airport. (<http://www.hotel-speeter.de/>).

The hotel is located in a picturesque village at the Deutsche Weinstraße and offers free parking and free WLAN access to the course participants.

Pickup & transfer by a limousine service from/to Frankfurt airport or from/to Mannheim train station is available at a one-way cost of 90 or 35 Euro, resp.

#### Offering:

- course material on CD (GAMS, presentations, examples, literature)
- full GAMS software with several solvers (temporary license)
- for the Basic & Advanced course: one of the following books: Book „Gemischt-Ganzzahlige Optimierung in der Praxis“ (Josef Kallrath, Vieweg 2002), or alternatively, „Business Optimization Using Mathematical Programming“ (Josef Kallrath & John M. Wilson, Macmillan)
- full board (3 nights, 3 x breakfast, 3 x lunch, 2 x dinner ) – basic
- full board (2 nights, 2 x breakfast, 2 x lunch, 1 x dinner ) – advanced course
- free analysis and consulting on participants' problems (send them in early)
- participants may, on request, obtain the course material prior to the course

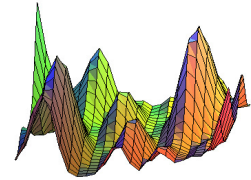
#### Prices:

- specified on the registration form (last page of this document)
- discounts on early registrations, or combined courses

#### Registration:

- fax the signed form (last page of this document) to GAMS GmbH
- or send your registration data by e-mail to [info@gams.de](mailto:info@gams.de)

We also offer in-house courses accommodated to the client's wishes. Contact us under [josef.kallrath@web.de](mailto:josef.kallrath@web.de) for further details.



## Basic GAMS Course – Modeling and Optimization with GAMS –

### Summary: GAMS Basic Course

This 3-days course helps the novice to become familiar with GAMS and to obtain the knowledge using GAMS to model and solve simple optimization problems. The participants will get an orientation on mathematical optimization, i.e., modeling and solution algorithms. After the course the participants will be able to map decision problems to the basic objects of optimization models: indices, data, variables, constraints and objective functions. The course does not assume the participants to have any knowledge on GAMS.

Besides presentation, examples and hands-on activities the course leaves enough time for discussions and own problems of the participants to be analyzed.

#### Target group of participants

The course is ideal for participants who wish to

- get an overview on mathematical optimization
- become familiar with the basic concepts of index sets, indices, variables, constraints and objective functions, and how to use these objects in GAMS
- get an overview on GAMS and what one can do with it
- learn how to implement optimization problems in GAMS
- bring their own optimization problems (the course offers a free analysis and, if possible a first implementation).

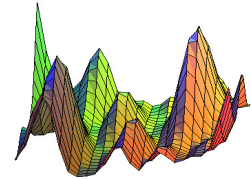
The participants may prepare their participations by communicating and specifying what they expect from this course and what sort of problems they want to solve.

#### Things to Do Before the Course

The course will be conducted on laptops of the participants. In case you do not yet have a GAMS system, the most recent version will be installed on your machine at the beginning of the course. Thus, it is recommended that your machine has administration rights in case some adjustments are needed. Note that course software, examples, presentations and useful literature will be distributed on CD-ROM. Tell us about your expectations, fields of interest and problems to be addressed prior to the course.

#### Course Language

All course material will be in English. The default course language is English. If *all* participants prefer the course in German language, the course will be hold in German.



## Part 1: Overview & Basic Objects in GAMS

**Day 1: (9:30-17:50) -- starting with Registration (coffee, tea, refreshments)**

### **Session 1a: Welcome and Introduction (9:30-10:00)**

- Introduction, course objectives, expectations of the participants
- Overview, the presentations and other materials
- Course structure on the CD, Preparing the Laptops

### **Session 1b: Foundations of Mathematical Optimization (10:00-11:15)**

- Optimization models and solution algorithms
- Algebraic modeling languages
- A simple example about cows and pigs

**Coffee break (11:15-11:30)**

### **Session 1c: Overview - Modeling with GAMS (Part I) (11:30-12:30)**

- The structure of a GAMS Program:
- Indices, variables, constraints and objective functions
- Model declaration, conditional operators, \$, and, or, ...
- Solve statement, interpretation of \*.log and \*.lst files and \*.log files

**Lunch break (12:30-14:00)**

### **Session 1c: Overview - Modeling with GAMS (Part II) (14:00-15:00)**

- GAMS IDE and the Cows & Pigs Example - Exercise

### **Session 2a: Sets (15:00-16:10)**

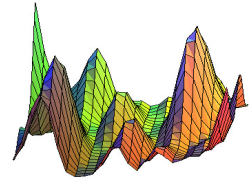
- Simple Sets and Multi-dimensional sets
- Subsets and domain checking
- Operations on Sets, operations on set elements, Dynamic Sets

**Coffee break (16:10-16:30)**

### **Session 2b: Data Objects (16:30-17:50)**

- Scalars, Scalars, parameters and tables
- Exercise: Cows & Pigs using Sets & Parameters
- Operations on scalars and parameters
- Exercises: Demand given per day and product – 6 tasks

**Dinner (18:00-19:30)**



**Day 2: (9:30-17:45)**

**Session 3a: Variables (09:30-10:00)**

- Declarations
- Attributes and assignment statements
- Display and variables in \*.lst files
- Using the solution values of variables

**Session 3b: Equations and Inequalities (10:00-11:30)**

- Declarations & Definitions
- Model declaration, Conditional operators, \$, and, or, ...
- ----- coffee break embedded in this exercise -----
- Exercises Boat: Model Building, implementation & debugging, interpretation

**Session 3c: Option Statement and Solver Communication (11:30-12:30)**

- GAMS Options: Solver (reslim, optcr, optca)
- Feedback mechanisms GAMS & Solver
- What you get after COMPILE / What you get after RUN
- Exercises: NLPexercise

**Lunch break (12:30-14:00)**

**Session 3d: Exercises: Modeling & Debugging (14:00-15:15)**

- Exercises Cutstock: Model Building and Implementation
- Exercises Cutstock: Debugging Compilation Errors

**Session 4a: Conditional Expressions (15:15-16:00)**

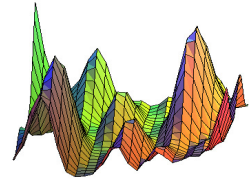
- Using the \$ Symbol in Conditional Expressions
- Logical Operators
- Exercises: Modifying the transport problem

**Coffee break (16:00-16:15)**

**Session 4b: Procedural Language Elements (16:15-17:45)**

- For, If, Loop, Repeat and While
- Exercise on FOR/WHILE: Complete Enumeration (Cows-Pigs)
- Exercises on IF/WHILE : Analyzing the points collected by a soccer team
- \$Exit, \$Goto and \$Label Statement

**Dinner (18:00-19:30)**



### **Day 3 (09:30-17:45)**

#### **Session B5a: Input Simple Text Files (09:30-10:30)**

- Feeding data into GAMS
- Reading csv-files (\$ondelim, \$offdelim)
- Exercises: Read the data from the “Cutstock” example from file

**Coffee break (10:30-10:45)**

#### **Session B5b: Output of Simple Text Files (10:45-12:15)**

- Put & Write facilities
- Formatted output
- *Report Generation: Put & Write-Facilities, Advanced Formatting, Put\_Uilities*
- Exercises: Output the results from the “Cutstock” example to files

**Lunch break (12:15-13:45)**

#### **Session 6: GAMS Usage (13:45-15:15)**

- GAMS Special Functions
- Compile-time versus Runtime Commands I - the \$ command
- Calling GAMS from Command Shells
- A Larger Application Example: Energy Portfolio Optimization

**Coffee break (15:15-15:30)**

#### **Session 7: Exercises: Modeling & Debugging (15:30-17:00)**

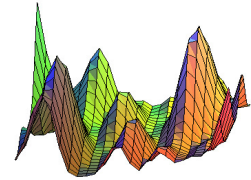
- Exercises: Model Building and Implementation
- Exercises: Debugging Compilation Errors
- Diagnosing Infeasibilities

#### **Session 8: GAMS Resources & Final discussion (17:00-17:45)**

- GAMSlib, GAMS Utilities, GAMS Web, GAMS Wiki-Support
- Outlook into the Advanced Course
- Final discussion

**End (17:45)**

**The agenda may change slightly !**



## Advanced Optimization Course – Modeling and Optimization with GAMS –

### Summary: GAMS Advanced Course

This 2-days course helps the mathematically inclined participants to learn advanced techniques for better using GAMS to model and solve larger or complicated optimization problems, especially, mixed integer optimization. The participants will increase their knowledge on using GAMS efficiently and will learn more about the procedural and modular language features, background on the solvers embedded in GAMS, how to interface to systems outside GAMS and how to use and create Function Libraries. The course assumes the participants to have some basic knowledge on GAMS and familiarity with the GAMS-IDE. For the mathematical part of this course, it helps if the participants have a decent mathematical background.

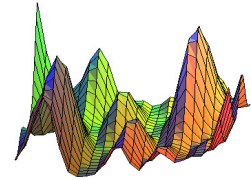
The participants will learn more about the MILP, NLP and MINLP solvers as well as on global optimization techniques. We stress that difficult and large optimization problems require a tight connection between modeling and algorithms aspects. This leads to sequence of models, nested solve statements, and decomposition techniques – detailed examples will be discussed. An important aspect of the course is the development of industrial applications software. The course will provide tricks-of-the-trade not covered by the GAMS documentation or other public sources.

Besides presentation, examples and hands-on activities the course leaves enough time for discussion and own problems of the participants to be analyzed.

### Target group of participants

The course is ideal for participants who wish to

- solve large and difficult problems and learn about approaches to attack them
- increase the efficiency with which they use GAMS
- use GAMS in a more modular way / learn how to use polyhedral modeling
- exploit the MIP restart feature in CPLEX in sequences of models
- learn more about nonlinear optimization and global optimization techniques
- reduce computer time and memory requirements
- enhancing the usefulness of GAMS output
- learn about GDX and link with other programs such as Excel or MS Access
- to find out about more powerful things GAMS can do that are not so well known because of hidden features or a lack of treatment in the documentation & tricks-of-the-trade



- to refresh their knowledge and learn more about more recent GAMS features
- bring their own GAMS models and problems (the course offers a free analysis and, in most cases, an improvement)
- repairing and fixing models which misbehave or do not produce solutions as wanted
- get inspiration on how to solve very difficult and large problems by hybrid methods combining LP, MILP, NLP, or MINLP with heuristics.

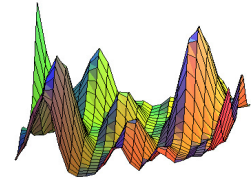
The participants may prepare their participations by communicating and specifying what they expect from this course and what sort of problems they want to solve.

### **Things to Do Before the Course**

In case you do not yet have a GAMS system, the most recent version will be installed on your machine at the beginning of the course. Thus, it is recommended that your machine has administration rights in case some adjustments are needed. In many cases the GAMS-IDE will be used, in some cases we might use DOS applications, or connect to Excel spreadsheets. Note that course software, examples, presentations and useful literature will be distributed on CD-ROM. Tell us about your expectations, fields of interest and problems to be addressed prior to the course.

### **Course Language**

All course material will be in English language. The default course language is English. If *all* participants prefer the course to be in German language, the course will be hold in German language.



## Part 1: LP & MILP / Procedural Structures / Sequential Models

**Day 1: (9:00-17:45) -- starting with Registration (coffee, tea, refreshments)**

### **Session 1a: Welcome and Introduction (9:00-9:30)**

- Introduction, course objectives, expectations of the participants
- Overview, the presentations and other materials

### **Session 1b: Foundations and GAMS Solvers (09:30-10:30)**

- Optimization problems and solution algorithms
- LP: Revised Simplex and Interior point methods
- MILP: Branch&Bound and Branch&Cut
- Warm-Up Exercise: Modeling a Set Covering Problem

**Coffee break (10:30-10:50)**

### **Session 1c: Modeling and GAMS-Features (10:50-12:30)**

- The art of modeling: BigM formulations, logical constraints, etc
- Equivalent linear formulations for special nonlinear problems
- Monolithic versus polyolithic models
  - standard versus tailor-made solution techniques
- ---- 10 minutes break ----
- Branching on special ordered sets and semi-continuous variables
- Procedural language elements in GAMS – Programming own B&B Schemes

**Lunch break (12:30-14:00)**

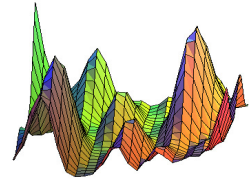
### **Session 2a: GAMS Advanced Usage (14:00-15:30)**

- Report Generation: Put & Write-Facilities, Advanced Formatting, Put\_Utilities
- Domain Check and Universe (\*) Declaration
- Compile-time versus Runtime commands II
- Compile-time parameters and calling GAMS from a DOS Command Shell
- \* Column enumeration in GAMS: calling a complete application from DOS
- \* Profiling and Tuning of CPLEX parameters

**Coffee break (15:30-15:50)**

### **Session 2b: GAMS Advanced Procedural Language Elements (15:50-17:00)**

- Sequences of models, modular structures in GAMS (\$macro & \$batinclude)
- Example: Explicit Domain Checking while Reading Data



**Session 3: Multi-criteria Optimization (17:00-17:30)**

- Foundations of multi-criteria optimization and Goal Programming
- Successive Problem Solving:
  - several MODEL and SOLVE statements
  - evaluating the results of a solve statement & generating the next model

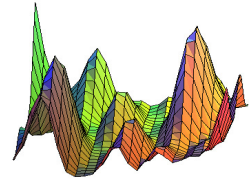
**Session 4: Difficult and Large-Scale Problems I (17:30-18:00)**

- What makes optimization problems difficult ?
- Column Enumeration and column generation
- Paper industry cutting stock example: Gilmore-Gomory approach

**Dinner (18:00-19:30)**

**The agenda may change slightly!**

**Topics indicated by \*  
are optional choices to be selected by the participants !**



## Part 2: NLP & MINLP & Global / Interfacing with GAMS / Hybrid Methods

### Day 2: (09:00-17:45)

#### Session 5a: Foundations of NLP and GAMS NLP Solvers (09:00-09:50)

- Foundations of nonlinear optimization: NLP ; GAMS & NLP
- Efficient formulations of NLP-problems
- Example “Molecule” with Solvers: MINOS, ConOpt, CoinIPOPT, SNOPT

#### Session 5b: GAMS Function Library Facility (09:50-10:30)

- Using Function Libraries / Creating Own Function Libraries
- Programming Own Functions

#### Coffee break (10:30-10:50)

#### Session 5c: MINLP & Global Optimization in GAMS (10:50-12:00)

- Foundations of mixed integer nonlinear optimization (MINLP)
- Example: Cutting Stock – MINLP formulation
- Foundations of Global optimization techniques
- Solvers: Global Solvers in GAMS (BARON & LINDOGLOBAL)
- Example: Molecule & Cutting circles from rectangles

#### Lunch break (12:00-13:15)

#### Session 6a: GDX and the GDX Utilities (13:15-14:30)

- GDX and the GDX Utility
- GAMS -- Excel: Data Import and Export

#### Session 6b: Interfacing with GAMS (14:30-15:15)

- Interfacing with GAMS
- Building Applications
- Running GAMS from Excel: Cutting Stock and other Examples

#### Coffee break (15:15-15:30)

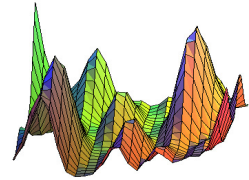
#### Session 7: Difficult and Large-Scale Problems II (15:30-17:00)

- Introduction and Examples to Hybrid methods and Fix-and-Relax Techniques
- Genetic Algorithm example in GAMS – Solving a non-convex NLP problem
- Hybrid example: (1+1) Evolutionary Algorithm + LP  
– Supply Management Problem with Lower-Bounded Demands

#### Session 8: Tricks, GAMS Resources & Final Discussion (17:00-17:45)

- Tricks-of-the Trade in GAMS: how to do .. ? Parallelization !
- GAMS Resources: GAMS Lib, GAMS Utilities, GAMS Web

**Josef Kallrath**  
Scientific Consultant



- Final discussion

## About the Lecturer

**Josef Kallrath** obtained his PhD in astrophysics from Bonn University (Germany) in 1989. He is a professor at the University of Florida (Gainesville, FL, [www.astro.ufl.edu/~kallrath](http://www.astro.ufl.edu/~kallrath)), and solves real-world problems in industry using a broad spectrum of methods in scientific computing, from modeling physical systems to supporting decisions processes by mathematical optimization. He has written review articles on the subject, about 70 research papers in astronomy and applied mathematics, and several books on mixed integer optimization, as well as one on eclipsing binary stars. Among the books relevant to this course are

*Business Optimization Using Mathematical Programming* (J. Kallrath & J. M. Wilson, 1997, Macmillan – now Palgrave)

*Gemischt-Ganzzahlige Optimierung in der Praxis* (J. Kallrath, 2002, Vieweg)

*Modeling Languages in Mathematical Optimization* (J. Kallrath, 2004, Kluwer)

*Real Optimization with SAP APO* (J. Kallrath and T. I. Maindl, 2006, Springer)

*Optimization in the Energy Industry* (J. Kallrath, Panos M. Pardalos, S. Rebennack, and S. Scheidt, Editors, 2008, Springer)

Josef Kallrath is an experienced consultant and course-instructor with in-depth knowledge related to modeling and optimization systems. Josef Kallrath has been providing consulting services to a wide range of industries, including energy, metals, paper, process, refineries, and telecommunication. He leads the *Real World Optimization Working Group* of the German Operations Research Society. His current research interests are polyhedral modeling approaches to solve large-scale or difficult optimization problems, for instance, by decomposition techniques such as column generation, or hybrid methods.

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**Thanks for your interest.  
We are looking forward to exciting courses.**

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# Registration GAMS Courses 2011

## in Weisenheim am Berg, Germany

Herewith, I register **bindingly** for the GAMS courses crossed below.

### 1. PERSONAL DATA

Name: \_\_\_\_\_  
Company: \_\_\_\_\_  
Street / P.O. box: \_\_\_\_\_  
ZIP code, city: \_\_\_\_\_  
Phone /Fax : \_\_\_\_\_  
E-Mail: \_\_\_\_\_

### 2. WORKSHOP FEE (CROSS WHAT FITS)

FEES INCL. 19% VAT

- |                          |   |           |
|--------------------------|---|-----------|
| <input type="checkbox"/> | B111 07.-09.11.2011 (early registration before 15.09.2011)      | € 3570,00 |
| <input type="checkbox"/> | B111 07.-09.11.2011 (registration after 15.09.2011)             | € 3927,00 |
| <input type="checkbox"/> | A111 10./11.11.2011 (early registration before 15.09.2011)      | € 2380,00 |
| <input type="checkbox"/> | A111 10./11.11.2011 (registration after 15.09.2011)             | € 2618,00 |
| <input type="checkbox"/> | B111+A111 07.-11.11.2011 (early registration before 15.09.2011) | € 4760,00 |
| <input type="checkbox"/> | B111+A111 07.-11.11.2011 (registration after 15.09.2011)        | € 5355,00 |

Please transfer the fee latest 5 days before the course to the following bank account:

**Recipient:** GAMS GmbH **Account No.** 3533320 **Bank Code:** 37070024

**IBAN** DE87 3707 0024 0353 3320 00 **BIC** (Swift Code): DEUT DEDBKOE

**Reason for payment:** GAMS Course 2011 – **Your Name & course, e.g. "B111+A111 early"**

### 3. ACCOMMODATION AND MEALS (CROSS WHAT FITS)

For the participants of the courses the hotel reservation is made automatically to a single non-smoking room from the night prior to the start of the course. If it applies, please cross what fits.

- |                          |                        |                          |                  |                          |  |
|--------------------------|------------------------|--------------------------|------------------|--------------------------|--|
| <input type="checkbox"/> | Smoking room.          | <input type="checkbox"/> | Vegetarian meals | <input type="checkbox"/> | Limousine airport transfer (2x90 Euro) |
| <input type="checkbox"/> | Extra follow-up night. | <input type="checkbox"/> | Double room      | <input type="checkbox"/> | Limousine Mannheim HBf (2x35 Euro)     |

#### Terms and Conditions

1. After the registration is received by GAMS GmbH, an invoice with payment instructions is send to the participants. Early-registration participants need to pay before Sep 25, 2011.
2. Upon receipt of payment, participants are eligible to download the course material.

With my signature below I agree to the Terms and Conditions.

\_\_\_\_\_  
Place, Date

\_\_\_\_\_  
Signature

**Please send your registration data to [info@gams.de](mailto:info@gams.de) or fax the form to:**  
**GAMS GmbH, Eupener Str. 135-137, 50933 Cologne, Germany**  
**Fax: +49-221-949-9171** **Version Jun 16, 2011 – page 12/12**