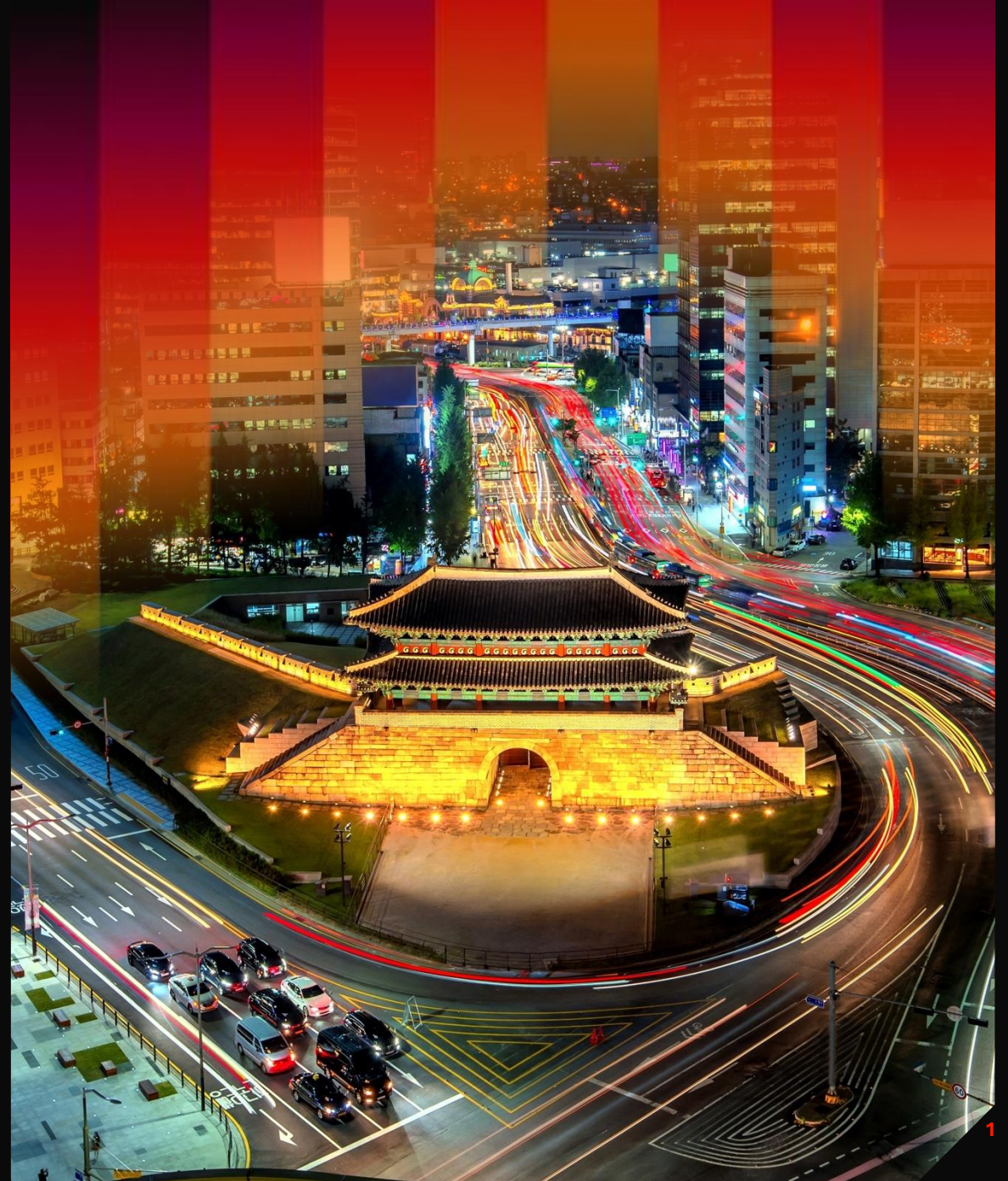


# Behind the Scenes of Support at Gurobi

Gurobi Day Korea 2026

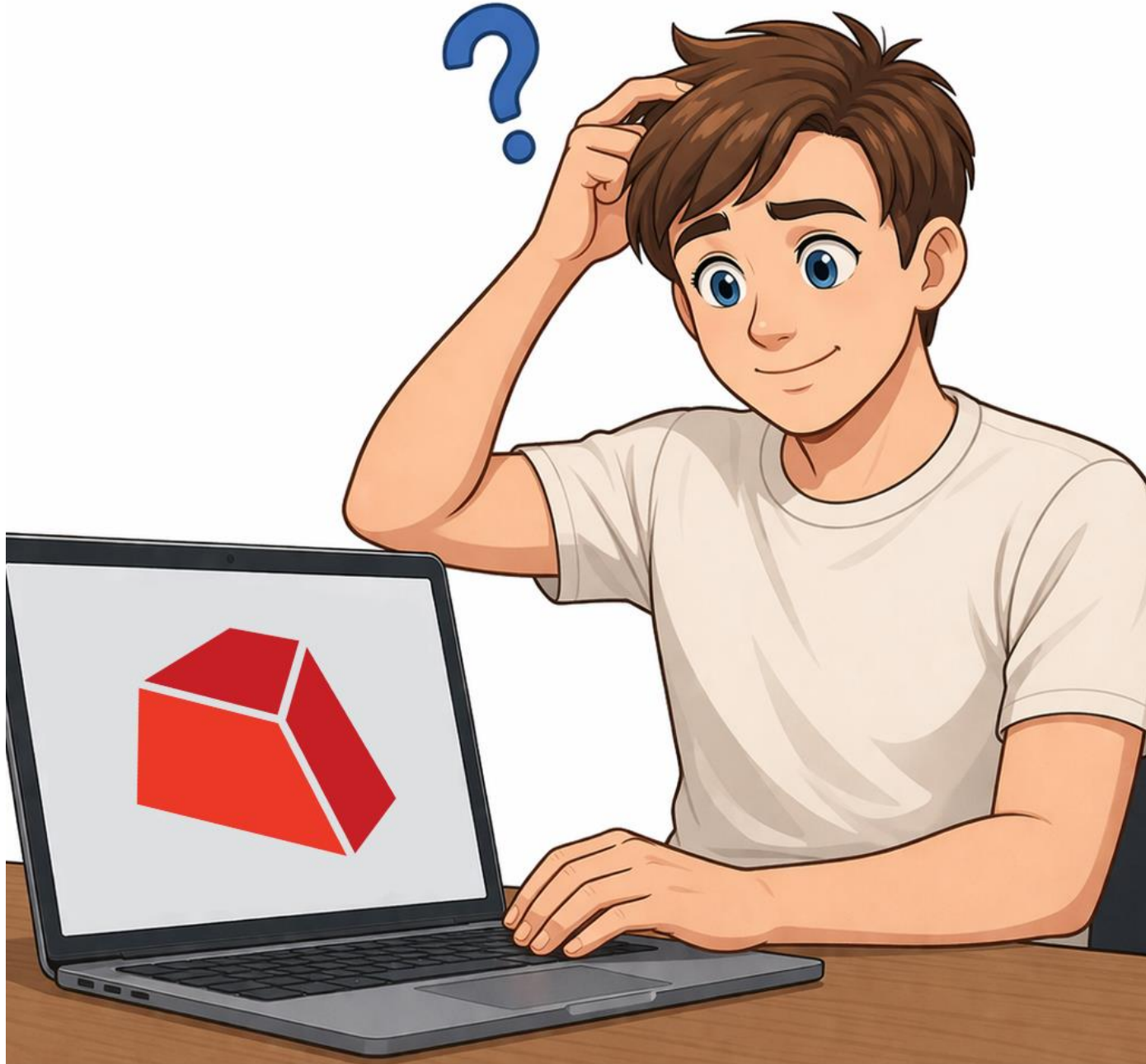


Dr Riley Clement  
Senior Optimization Engineer



# What I wish I knew before joining Gurobi





## Our story begins

- Young Riley looks confused.
- He wants to install gurobipy – the Python interface for Gurobi. But how?
- The answers lie waiting at the....

**Gurobi Help Center.**  
[support.gurobi.com](https://support.gurobi.com)

Welcome to the Gurobi Help Center.

🔍 Search

### Need help?

Start a chat with Gurobot, your AI-powered companion, or open a support request

Get instant answers, personalized guidance, code snippets, and direct links to the most relevant docs & knowledge base articles—plus open a support request when you need human assistance.

### Getting Started with Gurobi

Installation of, licensing for and assistance with using Gurobi

### Knowledge Base

Answers to common questions about using Gurobi

### What's New

Latest releases and other updates

# Getting started with Gurobi



**Gurobi** Status Community **Get Help** English (United States) Sign in

Welcome to the Gurobi Help Center.

Search

**Need help?**  
Start a chat with Gurobot, your AI-powered companion, or open a support request

Get instant answers, personalized guidance, code snippets, and direct links to the most relevant docs & knowledge base articles—plus open a support request when you need human assistance.

**Getting Started with Gurobi**  
Installation of, licensing for and assistance with using Gurobi

**Knowledge Base**  
Answers to common questions about using Gurobi

**What's New**  
Latest releases and other updates

# Getting started with Gurobi



Gurobi Help Center > Getting Started with Gurobi

Search


## Getting Started with Gurobi

*Installation of, licensing for and assistance with using Gurobi*

### Welcome to Gurobi Optimizer

*We're here to help you get started with instructions for installation, licensing, and more!*

- ★ [Getting Started with Gurobi Optimizer](#)



### Working with Gurobi Experts

- ★ [How do I get support for using Gurobi?](#)

### Navigating the Help Center

- ★ [Getting Started with the Gurobi Help Center](#)
- ★ [Posting to the Community Forum](#)

[When should I send an email to support@gurobi.com?](#)

[How do I submit a help request as a Commercial user?](#)

[How do I get support as an Academic user?](#)

[Badges on the Community Forum](#)

### Tutorials

*Learning to use Gurobi Optimizer*

- ★ [Coins Tutorial \(gurobi\\_cl\)](#)

support.gurobi.com/hc/en-us/articles/14799677517585-Getting-Started-with-Gurobi-Optimizer as an "Urgent" (production blocking)

# Getting started with Gurobi



The screenshot shows the Gurobi Help Center interface. At the top left is the Gurobi logo. To the right are navigation links: Status, Community, Get Help, English (United States) with a dropdown arrow, and Sign in. Below the navigation is a breadcrumb trail: Gurobi Help Center > Getting Started with Gurobi > Welcome to Gurobi Optimizer. On the right side of the page is a search bar with a magnifying glass icon and the text 'Search'. On the left side, under the heading 'Articles in this section', there is a link for 'Getting Started with Gurobi Optimizer'. The main content area features the article title 'Getting Started with Gurobi Optimizer' in a large font. Below the title is the author's profile picture and name 'Gwyneth Butera', along with the text '4 months ago · Updated' and a 'Follow' button. The article body begins with the text 'Welcome to Gurobi Optimizer! We're here to help you get started!' followed by the sub-heading 'Basic steps to get started with Gurobi Optimizer'. A bulleted list follows: '• First, [obtain a Gurobi license.](#)', '• Next, install [Gurobi Optimizer](#) or [Gurobi Compute Server](#).', '• Then, [retrieve and set up your license.](#)', '• Finally, [follow the installation and license.](#)', and '• Also see [How do I use the Gurobi setup diagnostic tool?](#)'. A hand cursor icon is positioned over the second bullet point. Below the list is the text 'Learn how to use Gurobi with some short tutorials' followed by another bulleted list: '• [Gurobi Command Line Interface \(gurobi\\_cl\) tutorial](#)', '• [Tutorials on using the Gurobi APIs](#)', '• [Jupyter tutorials](#)', '• [Resources for learning Mathematical Optimization](#)', and '• [Gurobi webinars on YouTube](#)'. At the bottom left of the page is a small black box containing the URL 'support.gurobi.com/hc/en-us/articles/4534161999889'. At the bottom center is the text 'Getting help with installing and using Gurobi'.

support.gurobi.com/hc/en-us/articles/4534161999889

Getting help with installing and using Gurobi

# Getting started with Gurobi



The screenshot shows the Gurobi Help Center interface. At the top, there is a navigation bar with the Gurobi logo, links for Status, Community, Get Help, English (United States), and Sign in. Below the navigation bar is a breadcrumb trail: Gurobi Help Center > Knowledge Base > Platforms and Installation > Installation. A search bar is located on the right side of the page. The main content area is divided into two columns. The left column, titled 'Articles in this section', lists several related articles: 'How do I install Gurobi for Python?', 'How do I use the Gurobi setup diagnostic tool?', 'How do I install Gurobi Optimizer?', 'How do I install Gurobi on a machine without internet access?', 'How do I install Gurobi for Java?', 'How do I use conda to install Gurobi in Anaconda?', 'How do I resolve the error "Could not find a version that satisfies the requirement" when installing Gurobi?', 'Using Gurobi's Matlab interface on macOS with Apple silicon (M1, M2)', and 'How do I update my Gurobi installation to a newer version?'. The right column features the article 'How do I install Gurobi Optimizer?' by Gwyneth Butera, updated 1 month ago. The article content includes: 'Before using Gurobi Optimizer, you'll need to install the software on your computer.', 'In case you have the Gurobi Optimizer already installed on your machine and you would like to upgrade, please skip to [Are you upgrading Gurobi?](#) section.', 'Python only: If you plan to use Gurobi from Python only, you can use pip to install Gurobi for Python or use our Anaconda package instead. Details on the differences in the installation methods can be found in [How do I install Gurobi for Python?](#)', and 'Full installation: When installing the full Gurobi product, your first steps are to visit [our download page](#), find your platform, and choose the corresponding file to download.' Below the article content is a 'Current Versions' section with a table for Gurobi Optimizer. A hand cursor icon is pointing to the 'Full installation' section.

**Articles in this section**

- How do I install Gurobi for Python?
- How do I use the Gurobi setup diagnostic tool?
- How do I install Gurobi Optimizer?
- How do I install Gurobi on a machine without internet access?
- How do I install Gurobi for Java?
- How do I use conda to install Gurobi in Anaconda?
- How do I resolve the error "Could not find a version that satisfies the requirement" when installing Gurobi?
- Using Gurobi's Matlab interface on macOS with Apple silicon (M1, M2)
- How do I update my Gurobi installation to a newer version?

## How do I install Gurobi Optimizer?

**Gwyneth Butera**  
1 month ago · Updated

Follow

Before using Gurobi Optimizer, you'll need to install the software on your computer.

In case you have the Gurobi Optimizer already installed on your machine and you would like to upgrade, please skip to [Are you upgrading Gurobi?](#) section.

### Python only

If you plan to use Gurobi from Python only, you can use pip to install Gurobi for Python or use our Anaconda package instead. Details on the differences in the installation methods can be found in [How do I install Gurobi for Python?](#)

### Full installation

When installing the full Gurobi product, your first steps are to visit [our download page](#), find your platform, and choose the corresponding file to download.

### Current Versions

Gurobi Optimizer		<a href="#">v13.0.0 Release Notes</a>	<a href="#">md5sums</a>
v13.0.0	Installer		md5 Checksum

# Getting started with Gurobi



The screenshot shows the Gurobi Help Center interface. At the top, there is a navigation bar with the Gurobi logo, a search bar, and links for Status, Community, Get Help, English (United States), and Sign in. The breadcrumb trail reads: Gurobi Help Center > Knowledge Base > Platforms and Installation > Installation. The article title is "How do I install Gurobi for Python?". The author is Riley Clement, who updated the article 5 days ago. A "Follow" button is visible. The article content states that Gurobi Optimizer for Python can be installed in three ways: using pip, conda, or offline installation. It notes that the installation is separate from any existing Gurobi installation and that users should only install into a 64-bit Python environment. The "Using pip (gurobipy)" section provides the command: `python -m pip install gurobipy`. The article also mentions that this command downloads the gurobipy extension from the public PyPI server and installs it into the current Python environment.

# Knowledge Base



**Gurobi** Status Community **Get Help** English (United States) Sign in

Welcome to the Gurobi Help Center.

Search

**Need help?**  
Start a chat with Gurobot, your AI-powered companion, or open a support request

Get instant answers, personalized guidance, code snippets, and direct links to the most relevant docs & knowledge base articles—plus open a support request when you need human assistance.


**Getting Started with Gurobi**  
Installation of, licensing for and assistance with using Gurobi

**Knowledge Base**  
Answers to common questions about using Gurobi

**What's New**  
Latest releases and other updates

# Knowledge Base



 [Status](#) [Community](#) [Get Help](#) [English \(United States\) ▾](#) [Sign in](#)

[Gurobi Help Center](#) > [Knowledge Base](#)

## Knowledge Base

*Answers to common questions about using Gurobi*

**Accounts and Licensing**  
*User Portal accounts and license keys*

- Gurobi User Portal**  
[See all 6 articles](#)
- Setting Up a License File with grbgetkey**  
[See all 15 articles](#)
- Academic and Research Licenses**  
[See all 23 articles](#)
- Floating Site (Token Server) Licenses**  
[See all 11 articles](#)
- Web License Service (WLS)**  
[See all 17 articles](#)

**Platforms and Installation**  
*Gurobi installation processes, APIs, and versions*

- Installation**  
[See all 7 articles](#)
- Installation, Building, and Linking**  
[See all 10 articles](#)
- APIs**  
[See all 6 articles](#)
- Version-Specific Information**  
[See all 5 articles](#)
- Architecture**  
[See all 8 articles](#)

**Modeling**  
*Reading, building, and writing models with Gurobi*

**Algorithms and Search**  
*Optimization algorithms and logging*

[support.gurobi.com/hc/en-us/sections/360009927512-Installation](https://support.gurobi.com/hc/en-us/sections/360009927512-Installation)



# Knowledge Base



**Gurobi** Status Community **Get Help** English (United States) Sign in

Gurobi Help Center > Knowledge Base > Platforms and Installation > Installation

Search

## Installation

Follow

*Installing Gurobi.*

- ★ How do I install Gurobi for Python?
- ★ How do I use Gurobi setup diagnostic tool?
- How do I install Gurobi Optimizer?
- How do I install Gurobi on a machine without internet access?
- How do I install Gurobi for Java?
- How do I use conda to install Gurobi in Anaconda?
- How do I resolve the error "Could not find a version that satisfies the requirement" when installing Gurobi?
- Using Gurobi's Matlab interface on macOS with Apple silicon (M1, M2)
- How do I update my Gurobi installation to a newer version?
- How do I check the version of my Gurobi installation?

### Articles in this section

[How do I install Gurobi for Python?](#)

[How do I use the Gurobi setup diagnostic tool?](#)

[How do I install Gurobi Optimizer?](#)

[How do I install Gurobi on a machine without internet access?](#)

[How do I install Gurobi for Java?](#)

[How do I use conda to install Gurobi in Anaconda?](#)

[How do I resolve the error "Could not find a version that satisfies the requirement" when installing Gurobi?](#)

[Using Gurobi's Matlab interface on macOS with Apple silicon \(M1, M2\)](#)

[How do I update my Gurobi installation to a newer](#)

## How do I install Gurobi for Python?



[Riley Clement](#)

5 days ago · Updated

Follow

You can install Gurobi Optimizer for Python in three different ways:

1. [Using pip](#)
2. [Using conda](#)
3. [Offline installation](#)

The installation, when using any of these methods, will be separate from any existing Gurobi installation you have on your machine. A [full Gurobi Optimizer installation](#) is not a dependency, and will not restrict which versions of Gurobi you install for Python.

Please note that you should only install Gurobi into a 64-bit Python installation.

### Using pip (gurobipy)

Starting with Gurobi 9.1, you can use pip to install Gurobi into your currently active Python environment:

```
python -m pip install gurobipy
```

This command instructs the called Python interpreter to download the `gurobipy` extension from the public PyPI server (<https://pypi.org>) and install it into your Python environment. After the installation

# Gurobot – Your “always on” Expert agent



The screenshot shows the Gurobi Help Center homepage. At the top left is the Gurobi logo. To the right are links for 'Status', 'Community', 'Get Help', 'English (United States) v', and 'Sign in'. Below the navigation is a dark blue banner with the text 'Welcome to the Gurobi Help Center.' and a search bar. The main content area features a large blue button for 'Need help?' with a hand cursor icon, and three smaller white buttons for 'Getting Started with Gurobi', 'Knowledge Base', and 'What's New'.

**Gurobi** Status Community **Get Help** English (United States) v Sign in

Welcome to the Gurobi Help Center.

Search

**Need help?**  
Start a chat with Gurobot, your AI-powered companion, or open a support request

Get instant answers, personalized guidance, code snippets, and direct links to the most relevant docs & knowledge base articles—plus open a support request when you need human assistance.

**Getting Started with Gurobi**  
Installation of, licensing for and assistance with using Gurobi

**Knowledge Base**  
Answers to common questions about using Gurobi

**What's New**  
Latest releases and other updates

# Gurobot – Your “always on” Expert agent



**Hi, I'm Gurobot. How can I help?**

I want to use Python to solve problems with Gurobi. How do I install it?



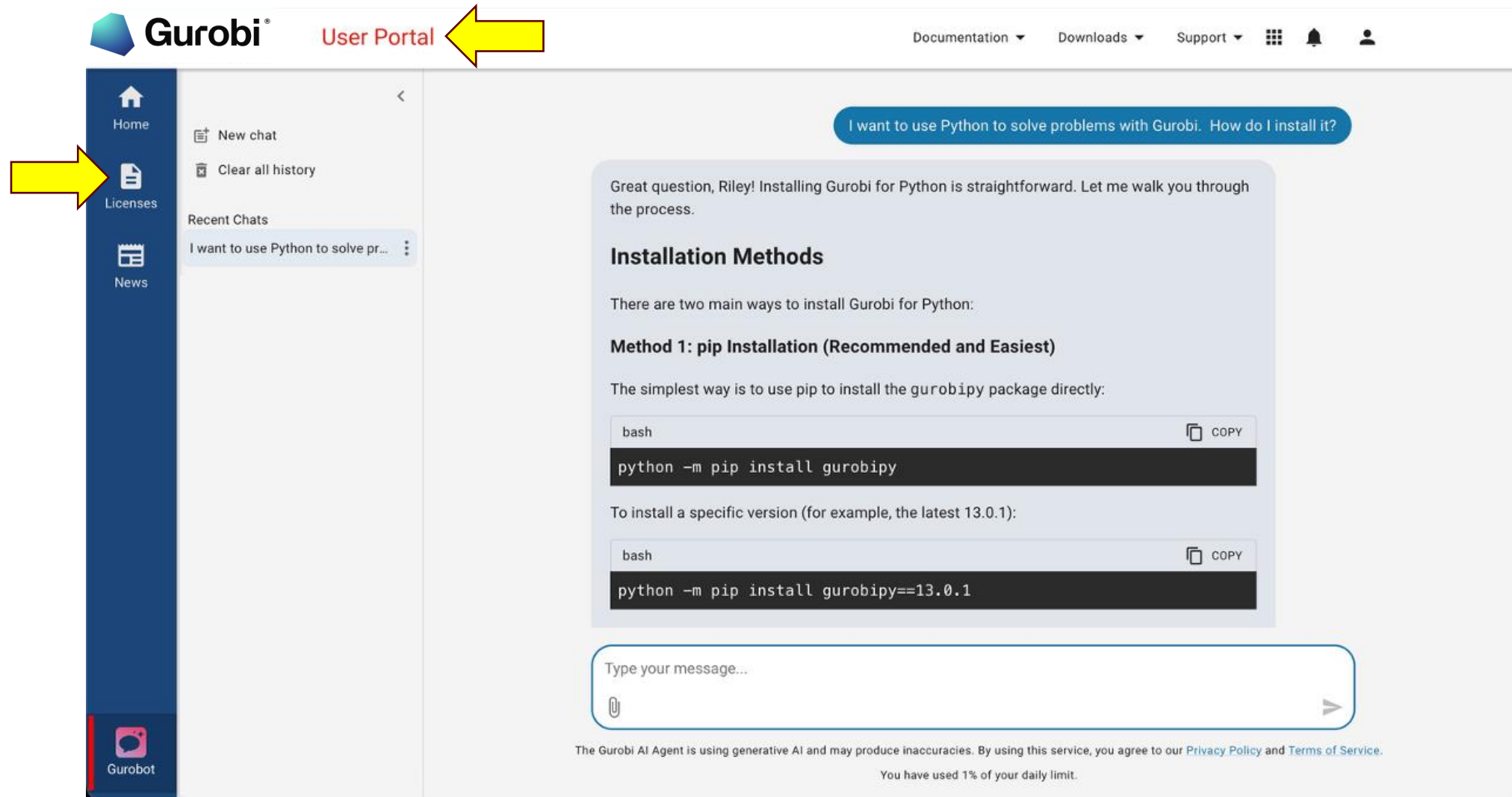
If needed, you can open a [support request](#) directly.

# Gurobot – Your “always on” Expert agent



The screenshot shows the Gurobi User Portal interface. On the left is a dark blue sidebar with navigation icons for Home, Licenses, News, and Gurobot. The main content area is split into two panes. The left pane shows a chat history with a 'New chat' button, a 'Clear all history' button, and a 'Recent Chats' section containing a chat titled 'I want to use Python to solve pr...'. The right pane shows an active chat window with a blue header containing the message 'I want to use Python to solve problems with Gurobi. How do I install it?'. Below the header is a list of reasoning steps: 'The user wants to know how to install Gurobi for Python. I should search the knowledge base for installation instructions for Gurobi with Python. Since no version was specified, I should use version 13.0 as per the guidelines.', 'Let me search the knowledge base for installation information.', 'Querying the knowledge base.', 'Good, I found information about installing Gurobi for Python. Let me search for more specific details about the installation process, including pip installation which is the most common method.', 'Querying the knowledge base.', 'Let me search for more comprehensive installation instructions from the official documentation.', and 'Querying the knowledge base.'. At the bottom of the chat window is a text input field with the placeholder 'Type your message...', a paperclip icon, and a send button. Below the chat window is a disclaimer: 'The Gurobi AI Agent is using generative AI and may produce inaccuracies. By using this service, you agree to our [Privacy Policy](#) and [Terms of Service](#). You have used 0% of your daily limit.'

# Gurobot – Your “always on” Expert agent



The screenshot displays the Gurobi User Portal interface. At the top left, the Gurobi logo and 'User Portal' text are visible, with a yellow arrow pointing to the 'User Portal' text. The top right navigation bar includes links for 'Documentation', 'Downloads', and 'Support', along with icons for a grid, a bell, and a user profile. A left sidebar contains navigation options: 'Home', 'Licenses', and 'News', with a yellow arrow pointing to the 'Licenses' option. The main chat area shows a user query: 'I want to use Python to solve problems with Gurobi. How do I install it?'. The Gurobot response provides instructions on installation methods, including a code block for pip installation. At the bottom, a disclaimer states: 'The Gurobi AI Agent is using generative AI and may produce inaccuracies. By using this service, you agree to our Privacy Policy and Terms of Service. You have used 1% of your daily limit.'

**Gurobi** User Portal

Documentation Downloads Support

Home Licenses News

New chat  
Clear all history

Recent Chats  
I want to use Python to solve pr...

I want to use Python to solve problems with Gurobi. How do I install it?

Great question, Riley! Installing Gurobi for Python is straightforward. Let me walk you through the process.

### Installation Methods

There are two main ways to install Gurobi for Python:

#### Method 1: pip Installation (Recommended and Easiest)

The simplest way is to use pip to install the `gurobipy` package directly:

```
bash  
python -m pip install gurobipy
```

To install a specific version (for example, the latest 13.0.1):

```
bash  
python -m pip install gurobipy==13.0.1
```

Type your message...

The Gurobi AI Agent is using generative AI and may produce inaccuracies. By using this service, you agree to our [Privacy Policy](#) and [Terms of Service](#).  
You have used 1% of your daily limit.

# Gurobot – it personalizes its response



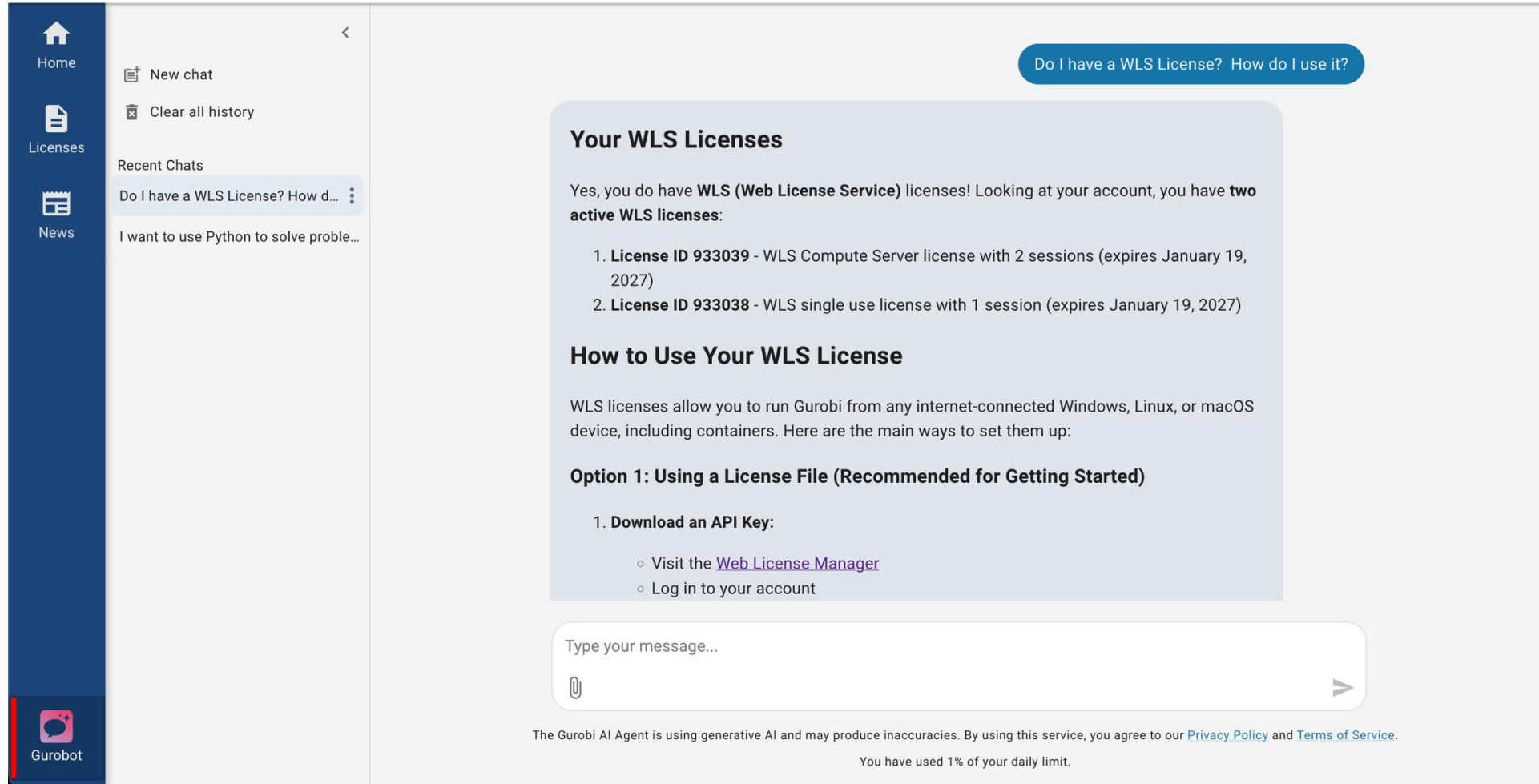
**Hi, I'm Gurobot. How can I help?**

Do I have a WLS License? How do I use it?



If needed, you can open a [support request](#) directly.

# Gurobot – it personalizes its response



Home

Licenses

News

Gurobot

New chat

Clear all history

Recent Chats

Do I have a WLS License? How d... ⋮

I want to use Python to solve proble...

Do I have a WLS License? How do I use it?

### Your WLS Licenses

Yes, you do have **WLS (Web License Service)** licenses! Looking at your account, you have **two active WLS licenses**:

1. **License ID 933039** - WLS Compute Server license with 2 sessions (expires January 19, 2027)
2. **License ID 933038** - WLS single use license with 1 session (expires January 19, 2027)

### How to Use Your WLS License

WLS licenses allow you to run Gurobi from any internet-connected Windows, Linux, or macOS device, including containers. Here are the main ways to set them up:

#### Option 1: Using a License File (Recommended for Getting Started)

1. **Download an API Key:**
  - Visit the [Web License Manager](#)
  - Log in to your account

Type your message...

The Gurobi AI Agent is using generative AI and may produce inaccuracies. By using this service, you agree to our [Privacy Policy](#) and [Terms of Service](#).

You have used 1% of your daily limit.

# Gurobot – helps you find resources



**Hi, I'm Gurobot. How can I help?**

I want to create models for portfolio optimization. What Gurobi resources are available that you would recommend?



If needed, you can open a [support request](#) directly.

# Gurobot – helps you find resources

I want to create models for portfolio optimization. What Gurobi resources are available that you would recommend?

Great question! Gurobi has excellent resources for portfolio optimization:

**1. Interactive Jupyter Notebook Examples**

...

**2. Reference Python Example (portfolio.py)**

...

**3. Key Modeling Capabilities**

...

**4. Advanced Modeling Techniques**

...

**5. Research Papers & Theory**

# Gurobot – helps you find resources

- 90% optimum solutions found (vs. 55% for competitors)
- 7% higher returns achieved in some cases

---


## What would be most helpful for you?

- Would you like me to help you get started with a specific portfolio optimization model?
- Are you interested in a particular aspect (basic mean-variance, cardinality constraints, transaction costs)?
- What programming language do you prefer (Python is most common for this application)?

Learn More:

- [Portfolio Optimization with Gurobi - Gurobi Optimization](#) ★★★★★
- <https://cdn.gurobi.com/wp-content/uploads/Brochure-updatev4.pdf> ★★★★★
- [Background & further reading](#) ★★★★★
- [Classic OR Examples](#) ★★★★★
- [portfolio.py](#) ★★★★★
- [Portfolio Optimization with Gurobi](#) ★★★★★
- [SwissQuant: Portfolio Optimization - Gurobi Optimization](#) ★★★★★



Create a support request 

# Gurobot – Your “always on” Expert agent

What's the best way to implement a piecewise linear function? ➤

How can I formulate a vehicle routing problem with time windows? ➤

Should I use indicator constraints variables or linear constraints for my problem? ➤

Can you show me how to add lazy constraints in Python? ➤

How do I implement callbacks in C++? ➤

Can you help me convert this CPLEX code to gurobipy code? ➤

How can I debug infeasibility in my model? ➤

Where can I find examples of network flow problems? ➤

# Gurobot – 언제든지 도움을 주는 전문가 에이전트



구간별 선형 함수를 구현하는 가장 좋은 방법은 무엇인가요? ➤

시간 제약(time windows)이 있는 차량 경로 문제를 어떻게 모델링할 수 있나요? ➤

제 문제에는 지시 제약(indicator constraints)을 사용해야 할까요, 아니면 선형 제약을 사용해야 할까요? ➤

Python에서 지연 제약(lazy constraints)을 추가하는 방법을 보여주실 수 있나요? ➤

C++에서 콜백(callback)을 어떻게 구현하나요? ➤

이 CPLEX 코드를 gurobipy 코드로 변환하는 것을 도와주실 수 있나요? ➤

제 모델의 비실현성(infeasibility)을 어떻게 디버깅할 수 있나요? ➤

네트워크 흐름 문제의 예시는 어디에서 찾을 수 있나요? ➤

# Gurobot – the gateway to the Experts



Hi, I'm Gurobot. How can I help?

~~I need my model to solve faster. Can you help?~~



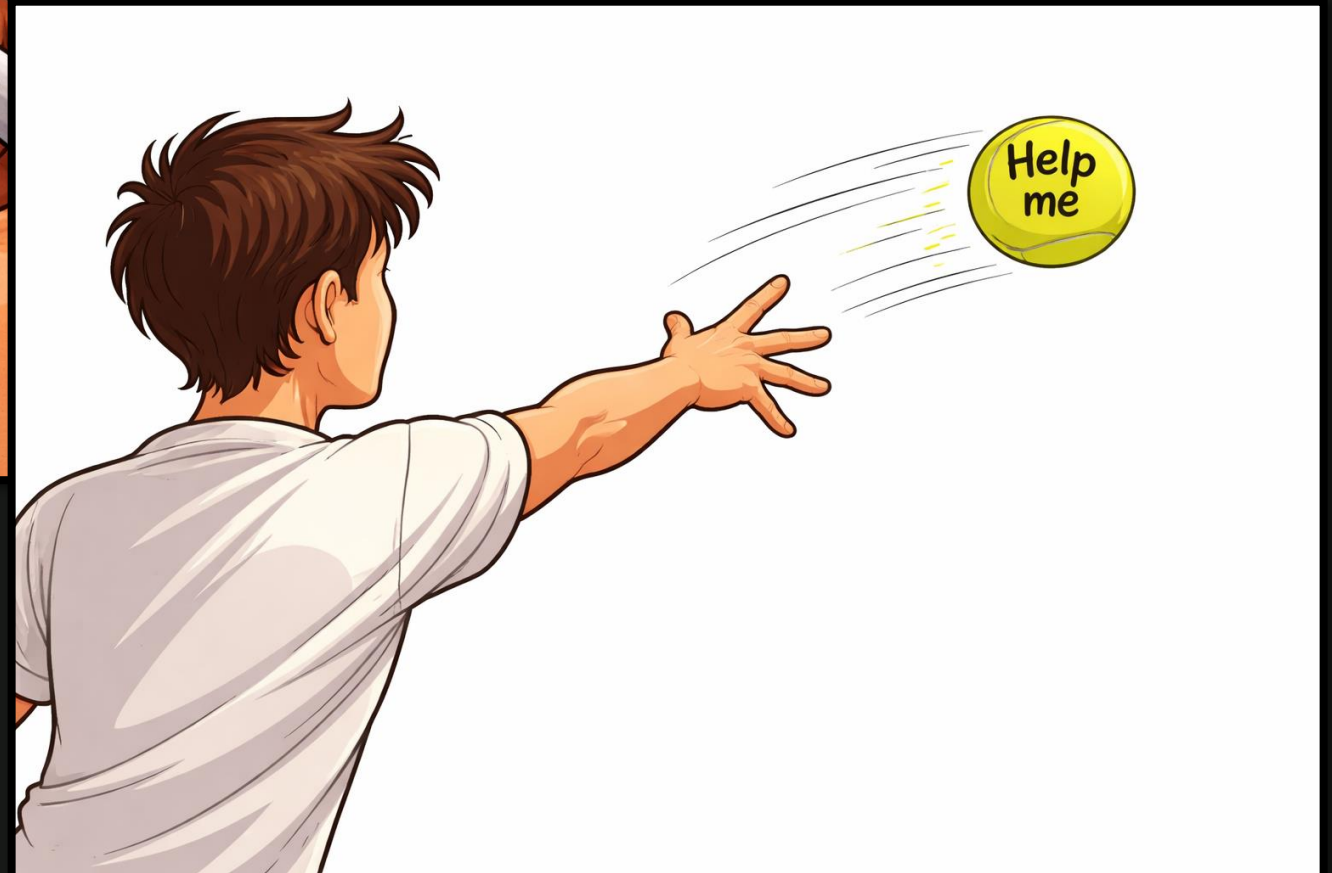
If needed, you can open a [support request](#) directly.



# Gurobot – the gateway to the Experts



The screenshot shows the Gurobi 'Submit a request' page. At the top, there is a navigation bar with the Gurobi logo, links for 'Status', 'Community', 'Get Help', and 'Requests', a language selector for 'English (United States)', and a user profile for 'Riley Clement'. Below the navigation bar, there is a breadcrumb trail 'Gurobi Help Center > Submit a request' and a search bar. The main heading is 'Submit a request'. Below this, there is a paragraph of instructions: 'Please describe your issue/request below, providing as much detail as possible. For more information, see [How do I get support for using Gurobi?](#)'. The form fields are: 'Please specify your current Gurobi usage or request type:' with a dropdown menu showing 'Commercial'; 'CC (only users registered on support.gurobi.com will receive CC emails)' with an empty text input; 'Subject\*' with an empty text input; 'Type of issue\*' with a dropdown menu showing '-'; and 'Description of issue/request\*' with a text area and a rich text editor toolbar below it.





# WATCHDOG

## Watchdog

- The Experts Team has a schedule that defines “who is Watchdog”
- The Watchdog is the person that is responsible for any new support requests
- The schedule provides around-the-clock support during the week





## A ticket has arrived!

- A **ticket** is another name for a support request
- When a new ticket arrives the Watchdog is alerted immediately
- For **production tickets**, the entire team is alerted.

Branch and Bound LLC

Alison Harcourt

**Open** Incident #114922

Requester

Alison Harcourt

Assignee\*

[take it](#)

Experts/Riley Cle...

Followers ⓘ

[follow](#)

Sharing

-

Form

Commercial

Tags

- 13.0.1 ×
- agent\_copilot\_enabled ×
- appeared\_in\_watchdog ×
- attachment\_consent ×
- country\_other ×
- customer\_replied ×
- ext-important ×
- liccheck\_failed ×
- + 5 more

Support category\*

Apply macro

Bug: infeasible model

24h | Via web form

[View ticket summary](#)



**Alison Harcourt** • 30 minutes ago

To: Alison Harcourt [Show more](#)

Hello support team! I am sending you a model from MIPLIB, where the following constraints have been removed: R1, R2, R6, R58  
Gurobi 13.0.1 reports it as infeasible. However, computing an IIS returns the error "Cannot compute IIS on a feasible model".



**Riley Clement** **Internal** • 23 minutes ago

I can reproduce this on our cluster machines with default parameter settings



**Simranjit Kaur** **Internal** • 12 minutes ago

It looks like the model is feasible or infeasible depending on the solution path, and this can be changed with the Seed parameter.



**Riley Clement** **Internal** • 2 minutes ago


Hi Developers,  
Can you please assist?  
The user has submitted a model, which may be on the edge of infeasibility. Is this behavior expected?  
Thanks,  
Riley


[Start internal note](#)

# Gurobi File Uploader

## Securely upload your files


**123** Ticket number if known  
114992

 Model application (e.g., vehicle routing)  
Scheduling

 Comment (max 1000 characters)  
This is a modified file from MIPLIB that is causing an issue when trying to compute IIS.

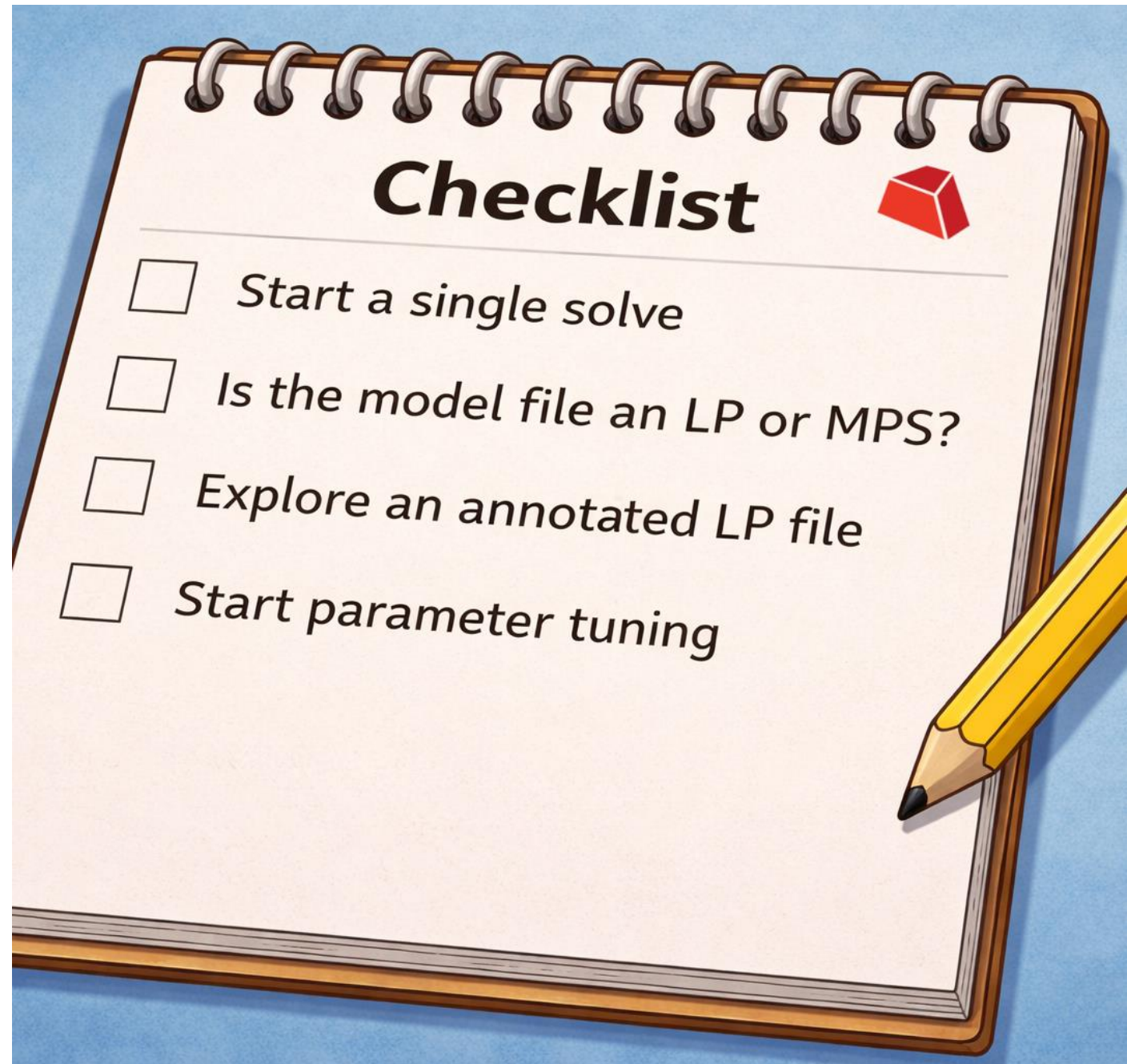
You can upload up to 10 files.

Files must be one of these types: .gz, .zip, .bz2, .tgz, .7z, .rar, .mat, .prm

 Drop files here or click

## We begin the journey

- Tickets usually involve at least one model file
- Tickets often involve parameter tuning
- Tickets sometimes include code reviews



# Start a single solve



`gurobi_cl` is Gurobi's command line tool

It is a quick way to run a model file and set parameters

It helps make a quick assessment of coefficient statistics

# | gurobi\_cl



```
gurobi_cl ~/gurobi1301/linux64/examples/data/glass4.mps
```

```
gurobi_cl TimeLimit=60 ~/gurobi1301/linux64/examples/data/glass4.mps
```

```
gurobi_cl ResultFile=glass4.sol ~/gurobi1301/linux64/examples/data/glass4.mps
```

# gurobi\_cl – licensing/connection parameters



```
alias gcl="gurobi_cl TokenServer=myserver.mydomain.com"
```

```
gcl ResultFile=iis.ilp /path/to/my/infeasible/model.mps.bz2
```

These values are always positive. They are the calculated from the absolute values.

Matrix range [1e-06, 8e+05]

Objective range [1e+00, 1e+06]

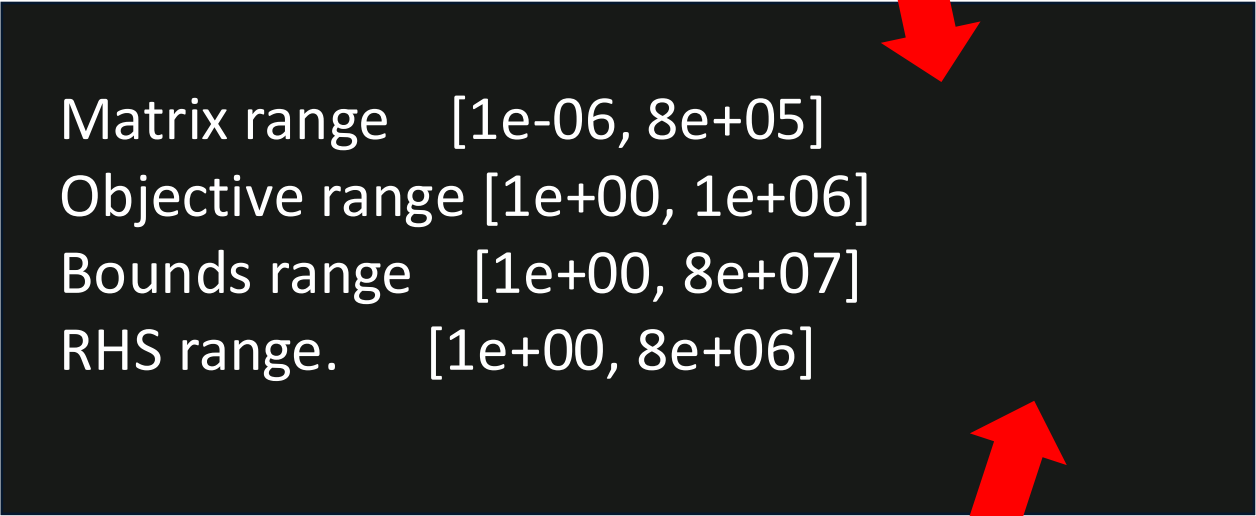
Bounds range [1e+00, 8e+07]

RHS range. [1e+00, 8e+06]

## Numerical health check

- See reference manual for examples of warnings that suggest numerical issues
- Are the coefficient statistics okay?

Matrix range spans 11 orders of magnitude. Should be less than 9 and ideally less than 6.



Matrix range [1e-06, 8e+05]  
Objective range [1e+00, 1e+06]  
Bounds range [1e+00, 8e+07]  
RHS range. [1e+00, 8e+06]

The largest bounds and RHS are close to  $1e+8$  and  $1e+7$  respectively. Ideally they should be less than  $1e+4$ .

## Numerical health check

- These statistics may suggest experimenting with particular parameters
- Maybe the model should be manually scaled by the modeller

## What have we learned?

- `gurobi_cl` is useful for running a model without needing to build it from scratch
- License or connection parameters can also be used with `gurobi_cl`
- Look for warnings in your logs
- Pay attention to the coefficient statistics and understand why they matter.



# Is the model file LP or MPS?

Model files can be saved in different formats.  
Each format has benefits and drawbacks.  
The two common formats are LP, and MPS



## LP files

glass4.lp

- Very readable for humans
- Easy to edit
- Notice the warning

```
≡ glass4.lp
  \ Model glass4
  \ LP format - for model browsing. Use MPS format to capture full model detail.
  Minimize
    2 x1 + 2 x2 + 2 x3 + 2 x4 + 2 x5 + 2 x6 + 2 x7 + 2 x8 + 2 x9 + 1e+06 x10
    + x11 + x12 + x13 + x14 + x15 + x16 + x17 + x18 + x19 + 0 x20
  Subject To
    c1: - x1 + x10 >= 700
    c2: - x2 + x10 >= 500
    c3: - x3 + x10 >= 200
    c4: - x4 + x10 >= 200
    c5: - x5 + x10 >= 500
    c6: - x6 + x10 >= 300
    c7: - x7 + x10 >= 100
    c8: - x8 + x10 >= 500
    c9: - x9 + x10 >= 300
    c10: 200 x11 - 200 x12 - 8.4e+06 x21 >= -8.36e+06
    c11: 300 x1 - 300 x2 - 8.4e+06 x21 >= -8.31e+06
    c12: 700 x11 - 700 x12 - 8.4e+06 x22 >= -8.05e+06
    c13: - 300 x1 + 300 x2 + 300 x11 - 300 x12 - 8.4e+06 x23 >= -8.13e+06
    c14: - 600 x1 + 600 x2 - 8.4e+06 x24 >= -7.98e+06
    c15: - 300 x11 + 300 x12 - 8.4e+06 x25 >= -8.28e+06
    c16: - 100 x1 + 100 x2 - 100 x11 + 100 x12 - 8.4e+06 x25 >= -8.32e+06
    c17: - 500 x11 + 500 x12 - 8.4e+06 x26 >= -8.15e+06
    c18: 100 x1 - 100 x2 - 50 x11 + 50 x12 - 8.4e+06 x27 >= -8.355e+06
    c19: - 250 x11 + 250 x12 - 8.4e+06 x27 >= -8.3e+06
    c20: 600 x1 - 600 x2 - 8.4e+06 x28 >= -8.1e+06
    c21: x21 + x22 + x23 + x24 + x25 + x26 + x27 + x28 = 1
    c22: 700 x11 - 700 x13 - 8.4e+06 x29 >= -7.91e+06
    c23: - 200 x1 + 200 x3 + 400 x11 - 400 x13 - 8.4e+06 x30 >= -8.02e+06
    c24: - 400 x1 + 400 x3 - 8.4e+06 x31 >= -8.04e+06
```



# MPS files

glass4.mps

- Hard to understand

## Sections:

- Constraint sense
- Matrix coefficients
- Constraint “right hand side”

```
≡ glass4.mps
1  NAME          glass4
   ROWS
   N  obj
   G  c1
   G  c2
   G  c3
   G  c4
   G  c5
   G  c6
   G  c7
   G  c8
   G  c9
   G  c10
   G  c11
   G  c12
   G  c13
   G  c14
   G  c15
   G  c16
   G  c17
   G  c18
   G  c19
   G  c20
   E  c21
   G  c22
   G  c23
   G  c24
   G  c25
   G  c26
   G  c27
```

```
≡ glass4.mps
      COLUMNS
      x1      obj      2      c1      -1
      x1      c11      300     c13     -300
      x1      c14     -600     c16     -100
      x1      c18      100     c20      600
      x1      c23     -200     c24     -400
      x1      c25     -200     c26     -300
      x1      c28     33.334014893  c29     -133.3340149
      x1      c31      120     c32      -20
      x1      c34     1100     c37     -200
      x1      c38     -400     c39     -200
      x1      c40      100     c41     -200
      x1      c42      100     c43      40
      x1      c44     -40     c45     100
      x1      c46      700     c49     -200
      x1      c50     -400     c51     -200
      x1      c52      100     c53     -200
      x1      c54      125     c55     -25
      x1      c56      200     c57      200
      x1      c58      400     c61     -800
      x1      c62     -200     c63      100
      x1      c64     -200     c65     166.66598511
      x1      c66     -66.66598511  c67      200
      x1      c68      300     c69      100
      x1      c70      400     c72      300
      x1      c74     -800     c75     -100
      x1      c76     66.665985107  c77     -66.66598511
      x1      c78     -100     c79      200
      x1      c80     -100     c81      200
      x1      c82      400     c84      200
```



# MPS files

glass4.mps

- Hard to understand

## Sections:

- Constraint sense
- Matrix coefficients
- Constraint “right hand side”

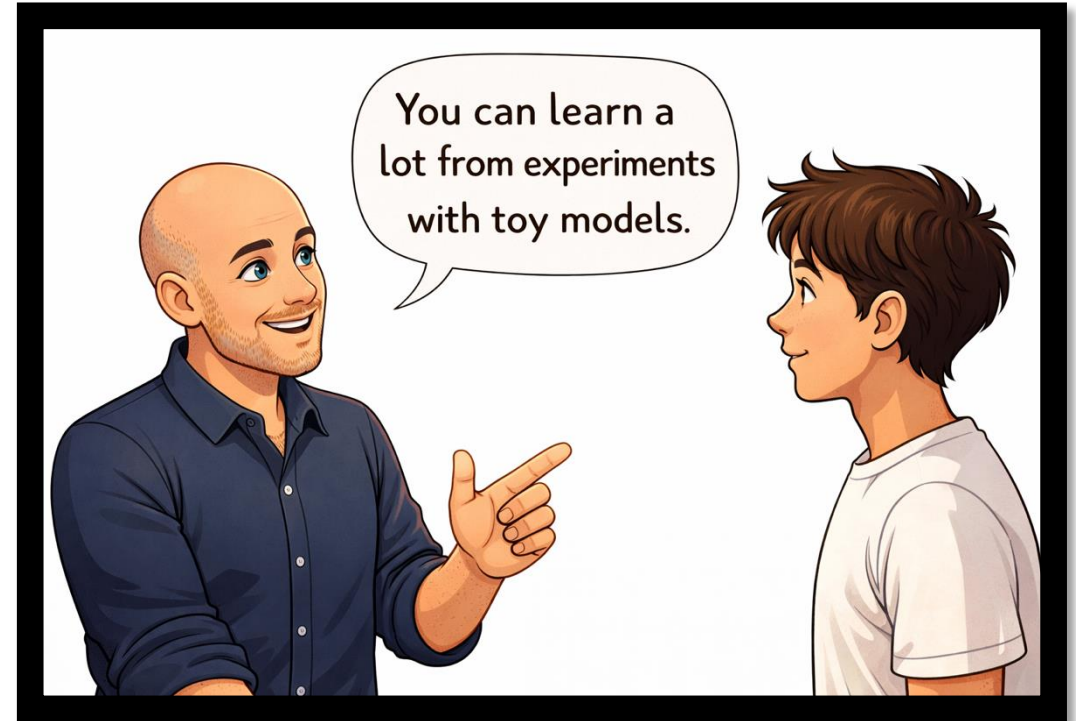
```
≡ glass4.mps
RHS
rhs      c1          700    c2          500
rhs      c3          200    c4          200
rhs      c5          500    c6          300
rhs      c7          100    c8          500
rhs      c9          300    c10         -8360000
rhs      c11         -8310000  c12         -8050000
rhs      c13         -8130000  c14         -7980000
rhs      c15         -8280000  c16         -8320000
rhs      c17         -8150000  c18         -8355000
rhs      c19         -8300000  c20         -8100000
rhs      c21          1    c22         -7910000
rhs      c23         -8020000  c24         -8040000
rhs      c25         -8240000  c26         -8190000
rhs      c27         -8320000  c28         -8390000 .613
rhs      c29        -8293332.789  c30         -8300000
rhs      c31         -8382000  c32         -8384000
rhs      c33         -8320000  c34         -8180000
rhs      c35          1    c36         -8000000
rhs      c37         -8200000  c38         -8040000
rhs      c39         -8180000  c40         -8390000
rhs      c41         -8240000  c42         -8330000
rhs      c43         -8396000  c44         -8368000
rhs      c45         -8320000  c46         -8260000
rhs      c47          1    c48         -7960000
rhs      c49         -8200000  c50         -8080000
rhs      c51         -8220000  c52         -8390000
rhs      c53         -8240000  c54         -8312500
rhs      c55         -8380000  c56         -8240000
rhs      c57         -8300000  c58         -8200000
```

# Experiment #1

```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= math.pi-3)
m.write("example.mps")
m.write("example.lp")
print(c.RHS)
```

0.14159265358979312



# Experiment #1 – write the model files



```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= math.pi-3)
m.write("example.mps")
m.write("example.lp")
print(c.RHS)
```

0.14159265358979312

```
example.mps
NAME
ROWS
  N OBJ
  L R0
COLUMNS
  C0 R0 1
RHS
  RHS1 R0 1.4159265358979312e-01
BOUNDS
ENDATA
```


# Experiment #1 – write the model files



```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= math.pi-3)
m.write("example.mps")
m.write("example.lp")
print(c.RHS)
```

0.14159265358979312



```
≡ example.mps
NAME
ROWS
  N  OBJ
  L  R0
COLUMNS
      C0          R0          1
RHS
      RHS1        R0          1.4159265358979312e-01
BOUNDS
ENDATA
```

```
≡ example.lp
Minimize

Subject To
  R0: C0 <= 0.1415926535897931
Bounds
End
```

# Experiment #1 – read the model files



```
m = gp.read("example.mps")  
print(m.getConstrs()[0].RHS)
```

0.14159265358979312

```
m = gp.read("example.lp")  
print(m.getConstrs()[0].RHS)
```

0.1415926535897931


```
≡ example.mps  
NAME  
ROWS  
  N  OBJ  
  L  R0  
COLUMNS  
  C0          R0          1  
RHS  
  RHS1      R0          1.4159265358979312e-01  
BOUNDS  
ENDATA
```

```
≡ example.lp  
Minimize  
  
Subject To  
  R0: C0 <= 0.1415926535897931  
Bounds  
End
```

## Experiment #2 – write the model files

```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= 68451.24)
m.write("example_2.mps")
m.write("example_2.lp")
print(c.RHS)
```



68451.24


# Experiment #2 – write the model files



```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= 68451.24)
m.write("example_2.mps")
m.write("example_2.lp")
print(c.RHS)
```

68451.24



```
≡ example_2.mps
NAME
ROWS
  N  OBJ
  L  R0
COLUMNS
      C0          R0          1
RHS
      RHS1        R0          68451.24
BOUNDS
ENDATA
```


# Experiment #2 – write the model files



```
import gurobipy as gp
import math

m = gp.Model()
x = m.addVar()
c = m.addConstr(x <= 68451.24)
m.write("example_2.mps")
m.write("example_2.lp")
print(c.RHS)
```

68451.24



```
≡ example_2.mps
NAME
ROWS
  N OBJ
  L R0
COLUMNS
  C0      R0      1
RHS
  RHS1    R0      68451.24
BOUNDS
ENDATA
```

```
≡ example_2.lp
Minimize

Subject To
  R0: C0 <= 68451.240000000001
Bounds
End
```

# Experiment #2 – read the model files



```
m = gp.read("example_2.mps")  
print(m.getConstrs()[0].RHS)
```

68451.24

```
m = gp.read("example_2.lp")  
print(m.getConstrs()[0].RHS)
```

68451.24

```
≡ example_2.mps
```

NAME

ROWS

N OBJ

L R0

COLUMNS

C0 R0 1

RHS

RHS1 R0 68451.24

BOUNDS

ENDATA

```
≡ example_2.lp
```

Minimize

Subject To

R0: C0 <= 68451.240000000001

Bounds

End

## Model files – the summary

- Use MPS files for sharing models
- Do not trust LP files to reproduce your model accurately
- Do not trust LP files to tell the truth about numbers
- But they are great for inspecting models!
- You should inspect your own models



# Exploring an annotated LP file

LP files are great for exploring models

We can annotate them to make it easier to understand their structure



## A more useful LP file?

```
import gurobipy as gp

m = gp.read("glass4.mps")

for v in m.getVars():
    vtype = "B" if v.vtype == "I" and (v.lb, v.ub) == (0,1) else v.vtype
    if vtype == "B":
        v.varname = f"{v.varname}_{vtype}"
    else:
        v.varname = f"{v.varname}_{v.lb}_{v.ub}_{vtype}"

m.write("glass4.lp")
```

From  
this

≡ glass4.lp

```
\ Model glass4
\ LP format - for model browsing. Use MPS format to capture full model detail.
Minimize
    2 x1 + 2 x2 + 2 x3 + 2 x4 + 2 x5 + 2 x6 + 2 x7 + 2 x8 + 2 x9 + 1e+06 x10
    + x11 + x12 + x13 + x14 + x15 + x16 + x17 + x18 + x19 + 0 x20
Subject To
c1: - x1 + x10 >= 700
c2: - x2 + x10 >= 500
c3: - x3 + x10 >= 200
c4: - x4 + x10 >= 200
c5: - x5 + x10 >= 500
c6: - x6 + x10 >= 300
c7: - x7 + x10 >= 100
c8: - x8 + x10 >= 500
c9: - x9 + x10 >= 300
c10: 200 x11 - 200 x12 - 8.4e+06 x21 >= -8.36e+06
c11: 300 x1 - 300 x2 - 8.4e+06 x21 >= -8.31e+06
c12: 700 x11 - 700 x12 - 8.4e+06 x22 >= -8.05e+06
c13: - 300 x1 + 300 x2 + 300 x11 - 300 x12 - 8.4e+06 x23 >= -8.13e+06
c14: - 600 x1 + 600 x2 - 8.4e+06 x24 >= -7.98e+06
c15: - 300 x11 + 300 x12 - 8.4e+06 x25 >= -8.28e+06
c16: - 100 x1 + 100 x2 - 100 x11 + 100 x12 - 8.4e+06 x25 >= -8.32e+06
c17: - 500 x11 + 500 x12 - 8.4e+06 x26 >= -8.15e+06
c18: 100 x1 - 100 x2 - 50 x11 + 50 x12 - 8.4e+06 x27 >= -8.355e+06
c19: - 250 x11 + 250 x12 - 8.4e+06 x27 >= -8.3e+06
c20: 600 x1 - 600 x2 - 8.4e+06 x28 >= -8.1e+06
c21: x21 + x22 + x23 + x24 + x25 + x26 + x27 + x28 = 1
c22: 700 x11 - 700 x13 - 8.4e+06 x29 >= -7.91e+06
c23: - 200 x1 + 200 x3 + 400 x11 - 400 x13 - 8.4e+06 x30 >= -8.02e+06
c24: - 400 x1 + 400 x3 - 8.4e+06 x31 >= -8.04e+06
```

To this

≡ glass4.lp

\ Model glass4

\ LP format - for model browsing. Use MPS format to capture full model detail.

Minimize

2 x1\_0.0\_inf\_C + 2 x2\_0.0\_inf\_C + 2 x3\_200.0\_inf\_C + 2 x4\_200.0\_inf\_C  
+ 2 x5\_100.0\_inf\_C + 2 x6\_200.0\_inf\_C + 2 x7\_200.0\_inf\_C  
+ 2 x8\_300.0\_inf\_C + 2 x9\_0.0\_inf\_C + 1e+06 x10\_0.0\_inf\_C  
+ x11\_0.0\_700.0\_C + x12\_0.0\_700.0\_C + x13\_0.0\_500.0\_C + x14\_0.0\_800.0\_C  
+ x15\_0.0\_800.0\_C + x16\_0.0\_600.0\_C + x17\_0.0\_700.0\_C + x18\_0.0\_500.0\_C  
+ x19\_0.0\_600.0\_C + 0 x20\_1.0\_1.0\_C

Subject To

c1: - x1\_0.0\_inf\_C + x10\_0.0\_inf\_C >= 700  
c2: - x2\_0.0\_inf\_C + x10\_0.0\_inf\_C >= 500  
c3: - x3\_200.0\_inf\_C + x10\_0.0\_inf\_C >= 200  
c4: - x4\_200.0\_inf\_C + x10\_0.0\_inf\_C >= 200  
c5: - x5\_100.0\_inf\_C + x10\_0.0\_inf\_C >= 500  
c6: - x6\_200.0\_inf\_C + x10\_0.0\_inf\_C >= 300  
c7: - x7\_200.0\_inf\_C + x10\_0.0\_inf\_C >= 100  
c8: - x8\_300.0\_inf\_C + x10\_0.0\_inf\_C >= 500  
c9: - x9\_0.0\_inf\_C + x10\_0.0\_inf\_C >= 300  
c10: 200 x11\_0.0\_700.0\_C - 200 x12\_0.0\_700.0\_C - 8.4e+06 x21\_B  
>= -8.36e+06  
c11: 300 x1\_0.0\_inf\_C - 300 x2\_0.0\_inf\_C - 8.4e+06 x21\_B >= -8.31e+06  
c12: 700 x11\_0.0\_700.0\_C - 700 x12\_0.0\_700.0\_C - 8.4e+06 x22\_B  
>= -8.05e+06  
c13: - 300 x1\_0.0\_inf\_C + 300 x2\_0.0\_inf\_C + 300 x11\_0.0\_700.0\_C  
- 300 x12\_0.0\_700.0\_C - 8.4e+06 x23\_B >= -8.13e+06  
c14: - 600 x1\_0.0\_inf\_C + 600 x2\_0.0\_inf\_C - 8.4e+06 x24\_B >= -7.98e+06  
c15: - 300 x11\_0.0\_700.0\_C + 300 x12\_0.0\_700.0\_C - 8.4e+06 x25\_B  
>= -8.28e+06  
c16: - 100 x1\_0.0\_inf\_C + 100 x2\_0.0\_inf\_C - 100 x11\_0.0\_700.0\_C

```
≡ modelXYZ.lp
  \ Model modelXYZ
  \ LP format - for model browsing. Use MPS format to capture full model detail.
  Minimize
    + 15 C37_0.0_5.1000000000000005_C + 15 C69_0.0_48.7_C + 15 C73_0.0_14.8_C
    + 15 C75_0.0_140.1_C - 7707.710894164771 C78_0.0_1.5_C
    - 7707.710894164771 C79_0.0_5.0_C + 15 C81_0.0_17.3_C + 15 C83_0.0_6.7_C
    + 15 C117_0.0_3.3000000000000003_C + 15 C137_0.0_3.6_C
    + 15 C139_0.0_1.4000000000000001_C + 15 C144_0.0_6.6000000000000005_C
    + 15 C150_0.0_10.6000000000000001_C + 15 C156_0.0_5.7_C
    + 15 C164_0.0_4.2_C + 15 C168_0.0_4.2_C
    + 15 C175_0.0_4.1000000000000005_C + 15 C176_0.0_3.8000000000000003_C
    + 15 C189_0.0_3.3000000000000003_C + 15 C195_0.0_1.6_C
    + 15 C197_0.0_2.4000000000000004_C + 15 C201_0.0_2.1_C
    + 15 C223_0.0_1.4000000000000001_C + 15 C231_0.0_1.5_C
    + 15 C237_0.0_1.5_C + 15 C240_0.0_2.6_C + 15 C242_0.0_1.5_C
    + 15 C255_0.0_9.3_C + 15 C258_0.0_4.0_C
    + 15 C271_0.0_1.9000000000000001_C + 15 C388_0.0_9.1_C
    + 15 C390_0.0_35.0_C + 15 C396_0.0_18.3_C + 15 C426_0.0_33.1_C
    + 15 C439_0.0_12.4_C + 15 C440_0.0_13.7000000000000001_C
    + 15 C443_0.0_47.5_C + 15 C449_0.0_45.2_C + 15 C453_0.0_16.5_C
    + 15 C455_0.0_8.9_C + 15 C461_0.0_59.0_C + 15 C464_0.0_25.5_C
    + 15 C466_0.0_18.4000000000000002_C + 15 C468_0.0_43.6_C
    + 15 C471_0.0_11.3_C + 15 C478_0.0_44.9000000000000006_C
    + 15 C489_0.0_14.2000000000000001_C + 15 C490_0.0_17.9000000000000002_C
    + 15 C493_0.0_14.2000000000000001_C + 15 C497_0.0_21.7000000000000003_C
    + 15 C504_0.0_41.4000000000000006_C + 15 C505_0.0_2.6_C
    + 15 C506_0.0_23.9000000000000002_C + 15 C515_0.0_14.5_C
    + 15 C522_0.0_25.2000000000000003_C
    - 3614.317577083 C536_0.0_14.7000000000000001_C + 15 C611_0.0_21.8_C
    + 15 C639_0.0_159.6000000000000002_C + 15 C641_0.0_141.3_C
```



## Why is this useful?

- This is a real customer example (and we'll refer to it a few times)
- There are some ugly upper bounds
- Is this their actual value?

```
≡ modelXYZ.lp
  \ Model modelXYZ
  \ LP format - for model browsing. Use MPS format to capture full model detail.
  Minimize
    C37_0.0_5.1000000000000005_C + 15 C69_0.0_48.7_C + 15 C73_0.0_14.8_C
    15 C75_0.0_140.1_C - 7707.710894164771 C78_0.0_1.5_C
    - 7707.710894164771 C79_0.0_5.0_C + 15 C81_0.0_17.3_C + 15 C83_0.0_6.7_C
    + 15 C117_0.0_3.3000000000000003_C + 15 C137_0.0_3.6_C
    + 15 C139_0.0_1.4000000000000001_C + 15 C144_0.0_6.6000000000000005_C
    + 15 C150_0.0_10.6000000000000001_C + 15 C156_0.0_5.7_C
    + 15 C164_0.0_4.2_C + 15 C168_0.0_4.2_C
    + 15 C175_0.0_4.1000000000000005_C + 15 C176_0.0_3.8000000000000003_C
    + 15 C189_0.0_3.3000000000000003_C + 15 C195_0.0_1.6_C
    + 15 C197_0.0_2.4000000000000004_C + 15 C201_0.0_2.1_C
    + 15 C223_0.0_1.4000000000000001_C + 15 C231_0.0_1.5_C
    + 15 C237_0.0_1.5_C + 15 C240_0.0_2.6_C + 15 C242_0.0_1.5_C
    + 15 C255_0.0_9.3_C + 15 C258_0.0_4.0_C
    + 15 C271_0.0_1.9000000000000001_C + 15 C388_0.0_9.1_C
    + 15 C390_0.0_35.0_C + 15 C396_0.0_18.3_C + 15 C426_0.0_33.1_C
    + 15 C439_0.0_12.4_C + 15 C440_0.0_13.7000000000000001_C
    + 15 C443_0.0_47.5_C + 15 C449_0.0_45.2_C + 15 C453_0.0_16.5_C
    + 15 C455_0.0_8.9_C + 15 C461_0.0_59.0_C + 15 C464_0.0_25.5_C
    + 15 C466_0.0_18.4000000000000002_C + 15 C468_0.0_43.6_C
    + 15 C471_0.0_11.3_C + 15 C478_0.0_44.9000000000000006_C
    + 15 C489_0.0_14.2000000000000001_C + 15 C490_0.0_17.9000000000000002_C
    + 15 C493_0.0_14.2000000000000001_C + 15 C497_0.0_21.7000000000000003_C
    + 15 C504_0.0_41.4000000000000006_C + 15 C505_0.0_2.6_C
    + 15 C506_0.0_23.9000000000000002_C + 15 C515_0.0_14.5_C
    + 15 C522_0.0_25.2000000000000003_C
    - 3614.317577083 C536_0.0_14.7000000000000001_C + 15 C611_0.0_21.8_C
    + 15 C639_0.0_159.6000000000000002_C + 15 C641_0.0_141.3_C
```



```
print(m.getVarByName("C37").ub)
```

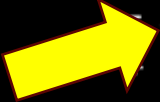


5.1000000000000005

```

≡ modelXYZ.lp
  \ Model modelXYZ
  \ LP format - for model browsing. Use MPS format to capture full model detail.
  Minimize
    C37_0.0_5.1000000000000005_C + 15 C69_0.0_48.7_C + 15 C73_0.0_14.8_C
    15 C75_0.0_140.1_C - 7707.710894164771 C78_0.0_1.5_C
    - 7707.710894164771 C79_0.0_5.0_C + 15 C81_0.0_17.3_C + 15 C83_0.0_6.7_C
    + 15 C117_0.0_3.3000000000000003_C + 15 C137_0.0_3.6_C
    + 15 C139_0.0_1.4000000000000001_C + 15 C144_0.0_6.6000000000000005_C
    + 15 C150_0.0_10.6000000000000001_C + 15 C156_0.0_5.7_C
    + 15 C164_0.0_4.2_C + 15 C168_0.0_4.2_C
    + 15 C175_0.0_4.1000000000000005_C + 15 C176_0.0_3.8000000000000003_C
    + 15 C189_0.0_3.3000000000000003_C + 15 C195_0.0_1.6_C
    + 15 C197_0.0_2.4000000000000004_C + 15 C201_0.0_2.1_C
    + 15 C223_0.0_1.4000000000000001_C + 15 C231_0.0_1.5_C
    + 15 C237_0.0_1.5_C + 15 C240_0.0_2.6_C + 15 C242_0.0_1.5_C
    + 15 C255_0.0_9.3_C + 15 C258_0.0_4.0_C
    + 15 C271_0.0_1.9000000000000001_C + 15 C388_0.0_9.1_C
    + 15 C390_0.0_35.0_C + 15 C396_0.0_18.3_C + 15 C426_0.0_33.1_C
    + 15 C439_0.0_12.4_C + 15 C440_0.0_13.7000000000000001_C
    + 15 C443_0.0_47.5_C + 15 C449_0.0_45.2_C + 15 C453_0.0_16.5_C
    + 15 C455_0.0_8.9_C + 15 C461_0.0_59.0_C + 15 C464_0.0_25.5_C
    + 15 C466_0.0_18.4000000000000002_C + 15 C468_0.0_43.6_C
    + 15 C471_0.0_11.3_C + 15 C478_0.0_44.9000000000000006_C
    + 15 C489_0.0_14.2000000000000001_C + 15 C490_0.0_17.9000000000000002_C
    + 15 C493_0.0_14.2000000000000001_C + 15 C497_0.0_21.7000000000000003_C
    + 15 C504_0.0_41.4000000000000006_C + 15 C505_0.0_2.6_C
    + 15 C506_0.0_23.9000000000000002_C + 15 C515_0.0_14.5_C
    + 15 C522_0.0_25.2000000000000003_C
    - 3614.317577083 C536_0.0_14.7000000000000001_C + 15 C611_0.0_21.8_C
    + 15 C639_0.0_159.6000000000000002_C + 15 C641_0.0_141.3_C

```



```
print(m.getVarByName("C37").ub)
```



5.1000000000000005

```

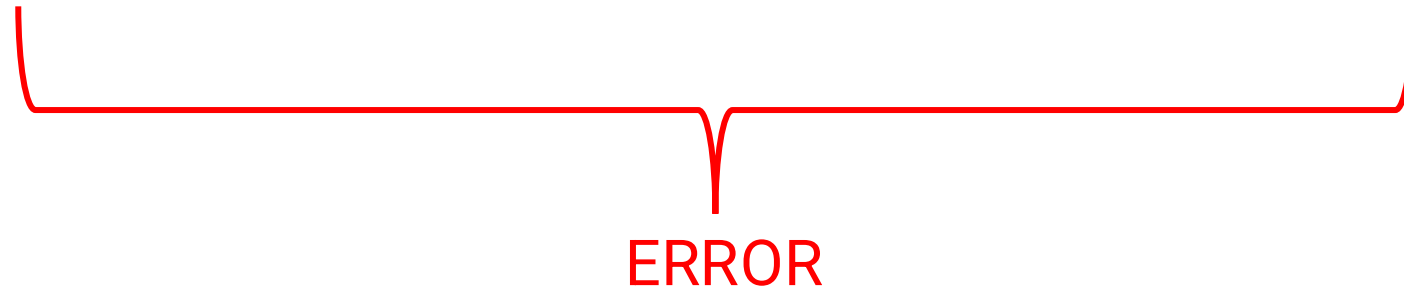
for v in m.getVars():
    diff = round(v.ub,2) - v.ub
    if abs(diff) < 1e-9:
        v.ub = round(v.ub,2)
m.update()

```

1.2x times faster

# Why did this help?

$$5.1 - 5.100000000000000005$$
$$= -0.000000000000000005$$



## Why did this help?

$$5.1 - 5.100000000000000005$$
$$= -0.000000000000000005$$

**Errors propagate**  
**Errors accumulate**  
**Errors cause numerical issues**  
**Numerical issues can slow the solver**

## Some errors are avoidable

**In theory:**  $\frac{1}{3}x + \frac{2}{3}y \leq 1$

### In practice:

Bad:  $0.33333x + 0.66666y \leq 1$

Better:  $0.33333333333333333333x + 0.66666666666666666666y \leq 1$

Best:  $1x + 2y \leq 3$

**Use integral data whenever possible!**

```
≡ modelXYZ.lp
```

```
Subject To
```

```
GC35: C2689_B = 0 -> 10 C940_0.0_50.8000000000000004_C  
+ 10 C957_0.0_163.9_C + 10 C975_0.0_19.1_C  
+ 10 C987_0.0_14.2000000000000001_C + 10 C1051_0.0_37.5_C  
+ 10 C1064_0.0_31.9000000000000002_C <= 0  
GC36: C2690_B = 0 -> 10 C823_0.0_6.8000000000000001_C  
+ 10 C824_0.0_1.2000000000000002_C + 10 C829_0.0_23.2000000000000003_C  
<= 0
```

$$x = 0 \Rightarrow \sum_i w_i y_i \leq 0$$

$$\Rightarrow y_i \leq 0 \quad \forall i$$

## Experimenting!

- While giving the model a health check we also look for opportunities to experiment
- Aggregation/disaggregation?

$$x = 0 \Rightarrow \sum_i w_i y_i \leq 0$$

$$\sum_i w_i y_i \leq \left( \sum_i w_i y^{ub} \right) x$$

$$x = 0 \Rightarrow y_i \leq 0 \quad \forall i$$

$$y_i \leq y^{ub} x \quad \forall i$$

## Aggregation & disaggregation

- Logically the same, when  $x$  is binary
- When  $x$  is not binary, such as in the linear relaxation these constraints are not the same

$$x = 0 \Rightarrow \sum_i w_i y_i \leq 0$$


$$\sum_i w_i y_i \leq \left( \sum_i w_i y^{ub} \right) x$$


$$x = 0 \Rightarrow y_i \leq 0 \quad \forall i$$

$$y_i \leq y^{ub} x \quad \forall i$$

## Aggregation & disaggregation

- The bottom constraints give a tighter linear relaxation
- One constraint vs many
- Hard to know which is better without experimenting

 1.3x faster

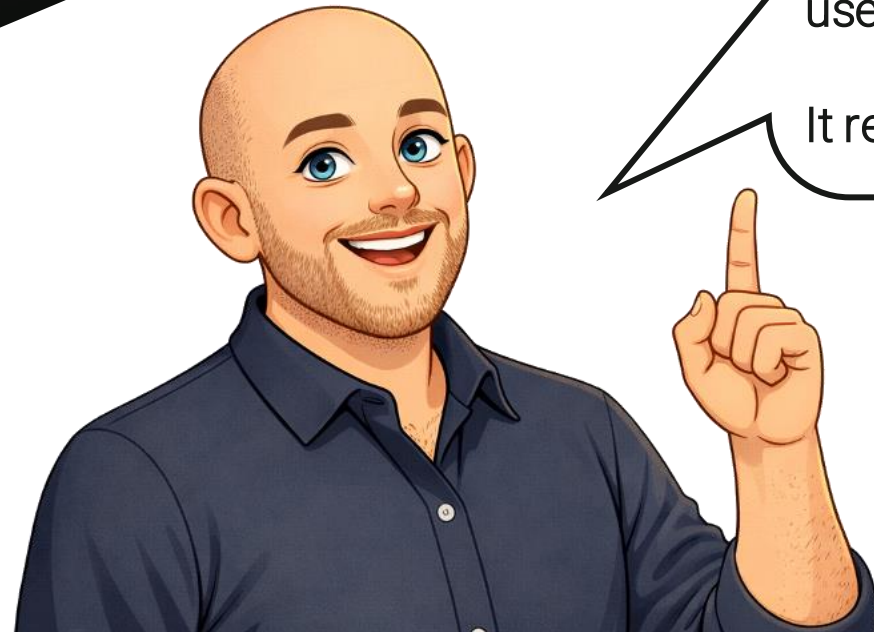
 1.5x faster (with clean bounds)

# Exploring the LP file – what to look for

- Do many variables have bounds?
- Data with small errors
- Data with rounding errors
  - Example: 3.142 (an approximation for  $\pi$ )
  - Example: 2.090909090909091 (=  $23/11$ )
- Is there anything unexpected?
- Opportunities to experiment



# Parameter tuning



A good parameter setting can speed up the solve!

Parameter selection is often not done well by users.

It requires a lot of computation to do it well.

# Parameter tuning

- Default values for parameters are chosen very carefully by our development team
- Default parameter values allow for the solver to have dynamic behavior
- Finding a good set of parameters can be done manually or with the automatic tuning tool
- Parameters should be re-tuned whenever the model changes significantly
- Parameters should be re-tuned when upgrading to a new Gurobi version





## Beware of over-tuning

Choosing parameters can feel like doing a good job...

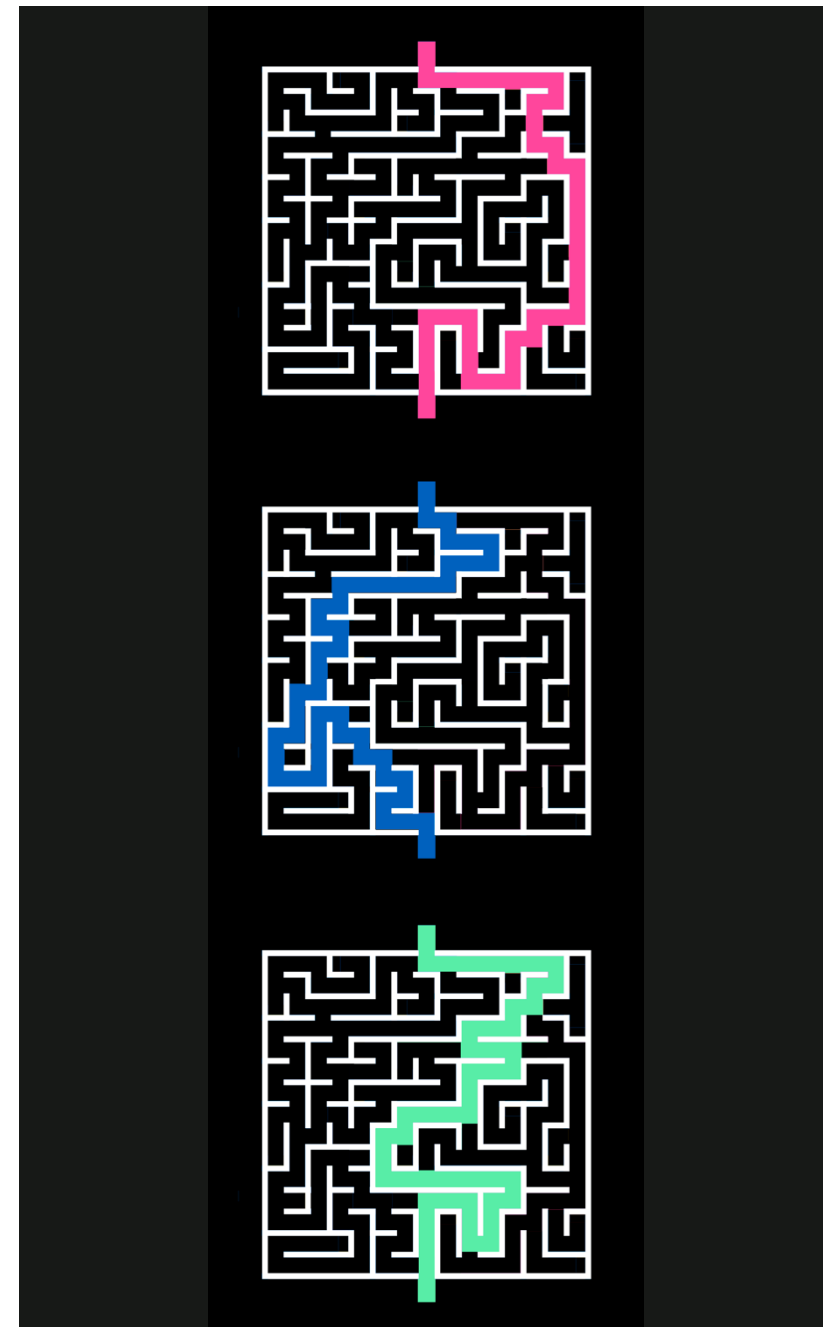
Overtuning is similar to overfitting machine learning models

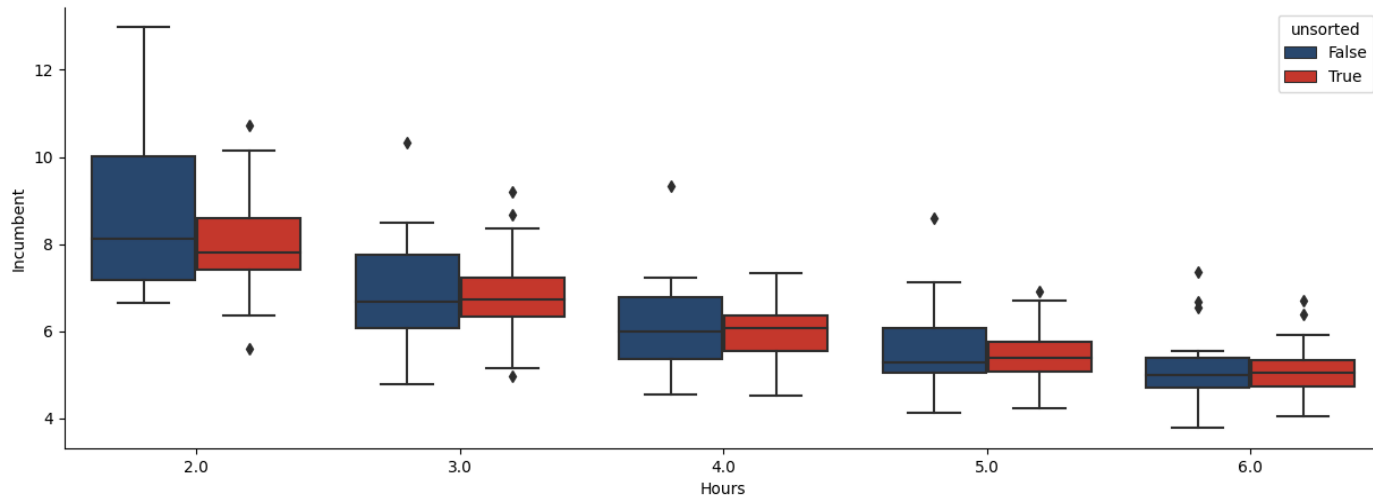
- if you overfit a ML model then it doesn't generalize to new data
- if you overtune Gurobi parameters then it doesn't generalize to new instances of the model

We ask for multiple instances of the same model, i.e. the same formulation but with different data

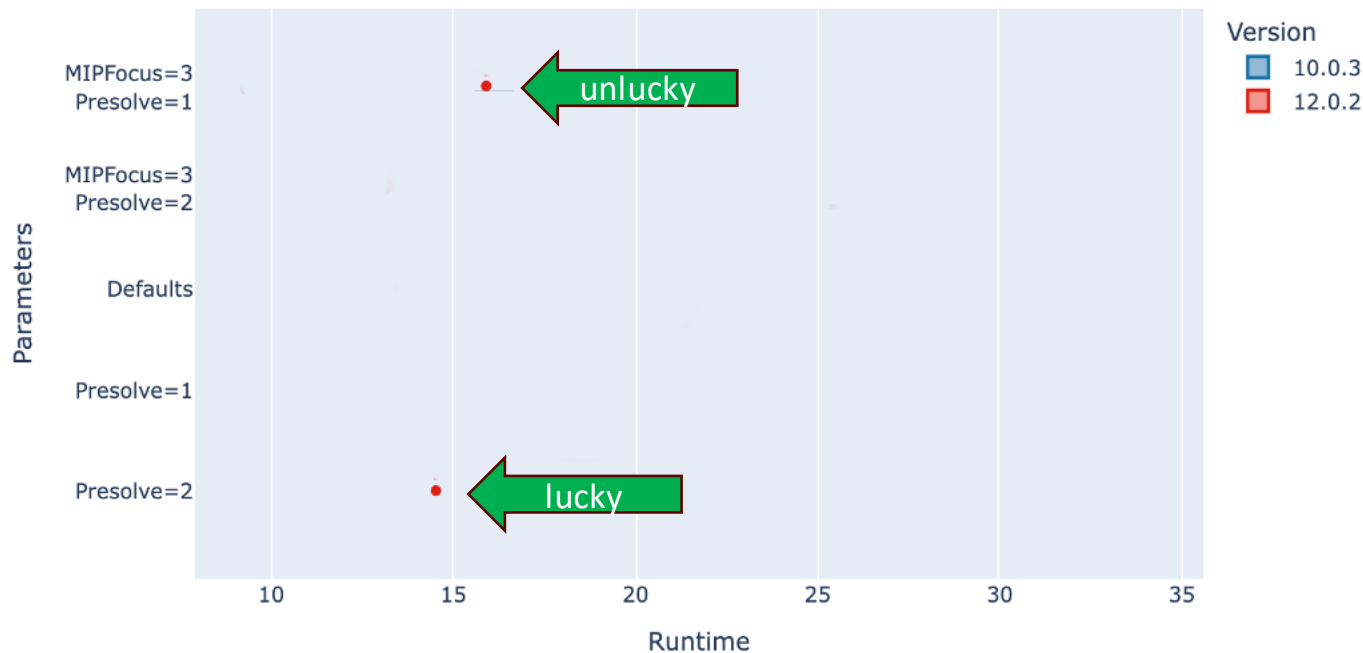
## The seed parameter

- There are many random choices made by during a solve
- The Seed parameter changes the decisions made
- Therefore the Seed parameter changes the solution path
- The solution path can also change when:
  - running on different machines
  - reordering variables or constraints
  - slight changes are made to the data
- It is an approximation for having many different instances





Parameters vs Version vs Runtime



## Accurate comparisons

By changing the Seed parameter we get a distribution of results, instead of a single result.

From a distribution we can understand the performance variance.

Comparing distributions is important for accurate comparisons and robust conclusions.



## Computation!

Let's say we want to test

- 100 parameter settings
- 10 Seeds per parameter setting
- 30 minute solve times

This is 500 hours of computation!

The support teams use a compute cluster with 140 machines



### Parameters

x	Runtime	▼
y	Parameters	▼
color	Version	▼
type	box	▼
points	all	▼
barmode	group	▼
symbol		▼

### Layout Controls

title	Parameters vs Version vs Runtime	
y axis label		
x axis label		
height:	0	
width:	800	
sort field	Runtime	▼
sort metric	mean	▼

Sort y axis   Sort x axis

### Toggles

- boxplot: show means
- boxplot: notched
- reverse ecdf
- show legend
- log(x)
- log(y)

Swap axes

Save config

Load config

### Palette

palette type	Gurobi	▼
palette	Gurobi_12	▼
<input checked="" type="radio"/> discrete <input type="radio"/> continuous		
<input type="checkbox"/> categorical color?		

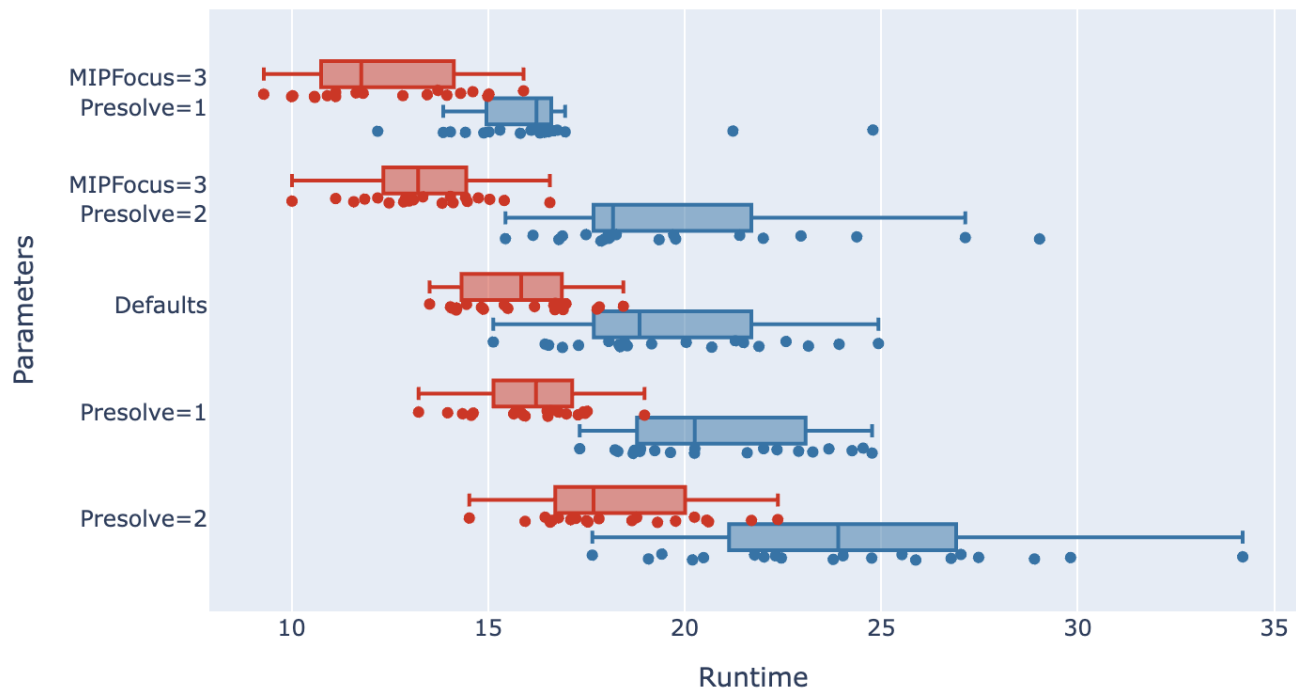
### DataFrame query string

``MIPFocus (Parameter)`.isin([0, 3])`

### Parameters to ignore

SoftMemLimit TimeLimit

### Parameters vs Version vs Runtime



Version  
■ 10.0.3  
■ 12.0.2

- parses log files
- provides plotting widgets
- makes analysis of results easy

# Parameter tuning on the example model

	Speed up
Cleaning errors in data	1.2x
+	
Disaggregating constraints	1.5x
+	
Parameter tuning	56x

# Parameter tuning – the summary

- Parameter settings should be backed by experimental evidence
- Alternative parameter settings should be evaluated by comparing distributions
  - This is also true for comparing alternative formulations you have for the same problem
  - This is also true for comparing Gurobi versions, and other solvers
- It requires a lot of computation to do well
- Expert knowledge and log file analysis help
- Beware of overtuning!



## Gurobi Support Brochure



Thank you!