

## Appendix A Linear and Mixed Integer Linear Program Solvers

Table A.1 outlines the open source and commercial solvers available in PuLP. There are many solvers outside of the ones listed here but these are some of the main ones. Note that all commercial solvers are available for free to university students and staff.

Out of the solvers listed, most were downloaded to run a benchmark to compare performance. Some open-source solvers could not be downloaded due to broken website links and difficulty in trying to setup on a Windows computer. Xpress was the only commercial solver that could not be downloaded due to the lengthy process required to setup an academic license.

**Table A.1:** List of open source and commercial solvers available in PuLP.

Open Source Solver	Commercial Solver
GLPK	CPLEX
PuLP CBC*	Gurobi
COIN	Mosek
Choco (Unavailable)	Xpress (Difficult to setup academic license)
MIPCL (Download page broken)	COPT
SCIP	
FSCIP (Current unavailable)	
HiGHS	

\*Comes with PuLP library.

## A.1 Benchmarks

To provide an overview of the speed and capabilities of the solvers, a test bench was setup. Since the overarching problem is a MILP, the MIPLIB 2017 benchmark library was used. This library contains 240 MILPs that are solvable and have a known solution [152]. At the time of writing, late 2024, submissions are open for the MIPLIB 2024 library. Since this set of problems was not available at the time of the project, the 2017 set was used.

To compare solvers, a script was setup that iterated through each solver and the first 50 problems in the MIPLIB 2017 library. Only the first 50 problems were benchmarked due to the time constraints of the project. Furthermore, each solver was given a time limit of 1 hour to try and solve these problems. Despite only benchmarking the first 48 (due to errors in reading 2 of the files, only 48 of the 50 were tested) problems, there were a range of problems and difficulty levels in these first 48 to compare the solvers [153]. There are also extensive benchmarks available for some of the solvers listed in Table A.1 conducted by Hans D Mittelman [154], [155].

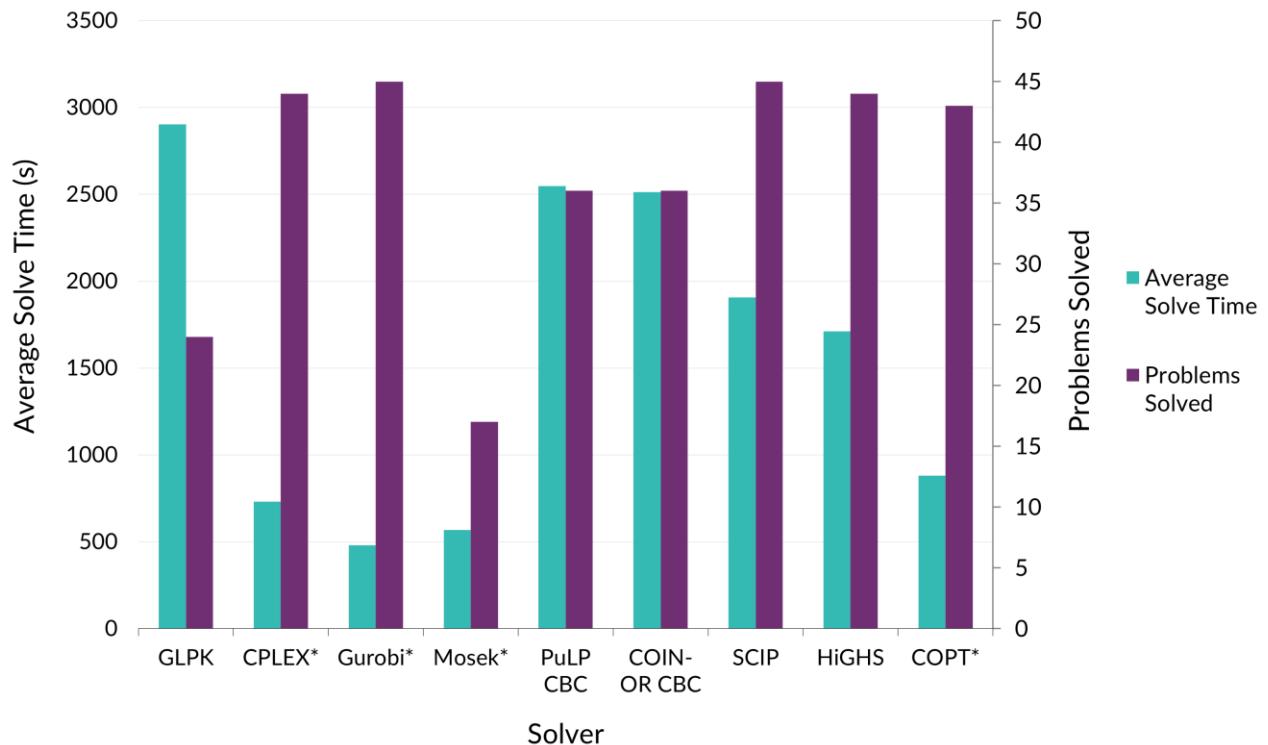
A visualisation of the solver performances is shown in Figure A.1. Note that if the solver was unable to solve the problem in the given time, the entry is marked with ‘Not Solved’. Surprisingly, SCIP, an open-source solver, and Gurobi were able to complete the most problems. However, the Gurobi solver was able to do so in less than a quarter of the time.

As shown in Figure A.1, Gurobi was the best performing solver in terms of speed. Of the open-source solvers, SCIP was the best performer in terms of number of problems. Despite the HiGHS solver completing 2 problems less than SCIP, it had a faster solve time. Of the commercial solvers, Mosek performed the worst, solving less problems than all the open-source solvers. However, the problems that it did solve, it did so quickly as can be seen by its low average solve time.

This analysis highlights the power of the speed of commercial solvers. For illustrative purposes, Gurobi was one of the only solvers that could complete the entire 48 problem set overnight whereas the open-source solvers had to be tested over multiple nights. However, this speed comes at the cost of a license. On the other hand, SCIP and HiGHS were shown to be capable open-source solvers, with SCIP solving the same number of problems as Gurobi. However, one drawback of these solvers is their speed.

It should also be noted that these benchmarks were only performed on the first 48 problems of the 240 MIPLIB 2017 set. Thus, the results could be different on the complete set of problems.

## Comparison of Commerical\* and Open-Source Optimisation Solvers



**Figure A.1:** Comparison of commercial and open-source solvers on the first 48 problems of the MIPLIB 2017 benchmarks. Lower average solve time is better and a higher number of problems solved is better.

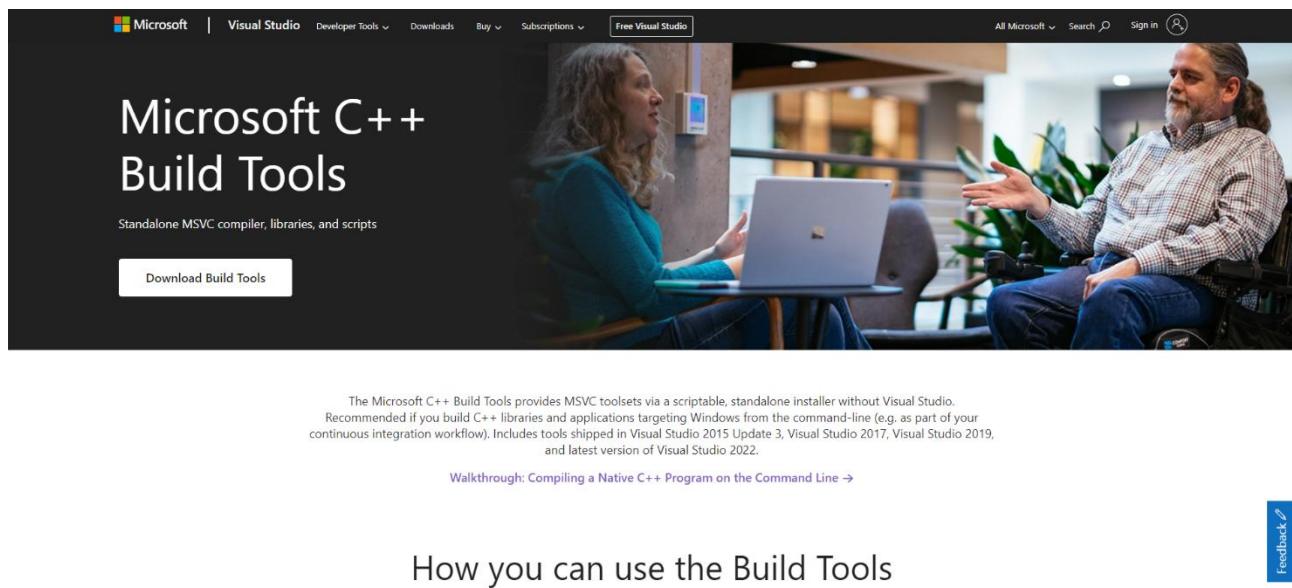
## A.2 Solver Installation Guide

The following sections outline the process of installing each solver. The first installation guides discuss the prerequisites needed to ensure that the solvers will work. Subsequent sections outline the installation methods required for each solver investigated. Some solvers can either be installed directly in the Python environment or their executable can be downloaded and added as an environmental variable to be accessed from anywhere on a computer. Note that the subsequent sections will follow a procedural structure.

### Microsoft Visual Studio

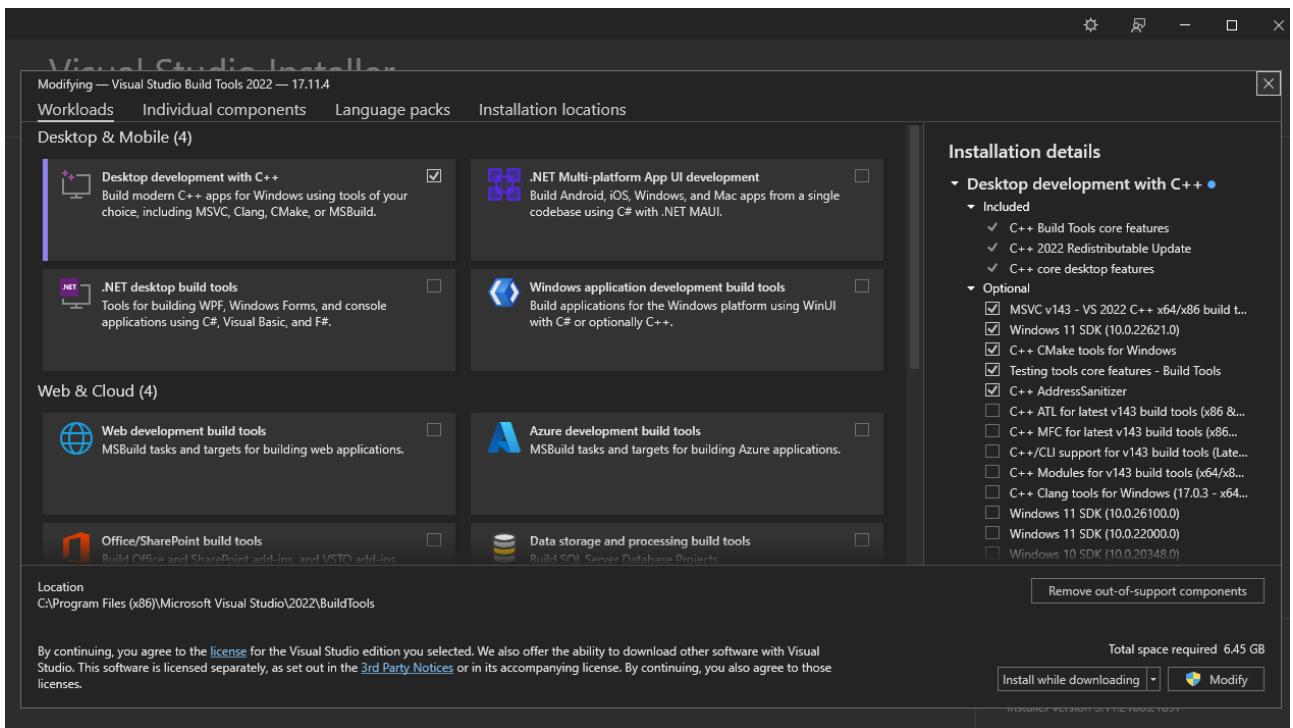
For some of the solvers to work, Microsoft Visual Studio Build Tools is required. The following procedure outlines the installation steps of this software.

1. Navigate to the following webpage <https://visualstudio.microsoft.com/visual-cpp-build-tools/>.
2. Click on the ‘Download Build Tools’ button as shown in Figure A.2.



**Figure A.2:** Microsoft Visual Build Tools download page.

3. Run the downloaded executable file.
4. Click on the ‘Desktop development with C++’ option on the screen shown in Figure A.3.
5. Click ‘Install’ located in the bottom right-hand corner of the screen shown in Figure A.3. Note that build tools were already installed on the demonstration device so the install button which will be located at the same spot as the modify button.

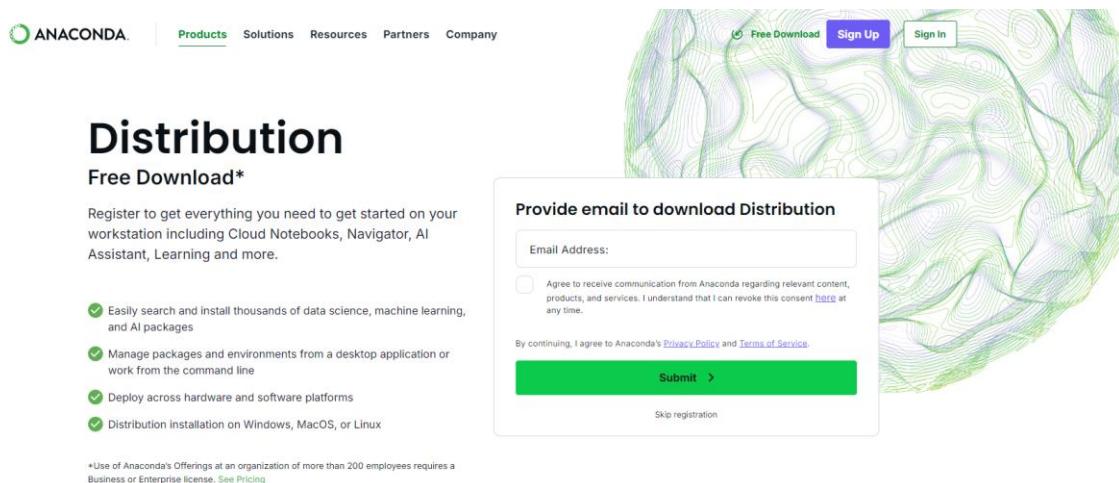


**Figure A.3:** Microsoft Visual Build Tools application installation page.

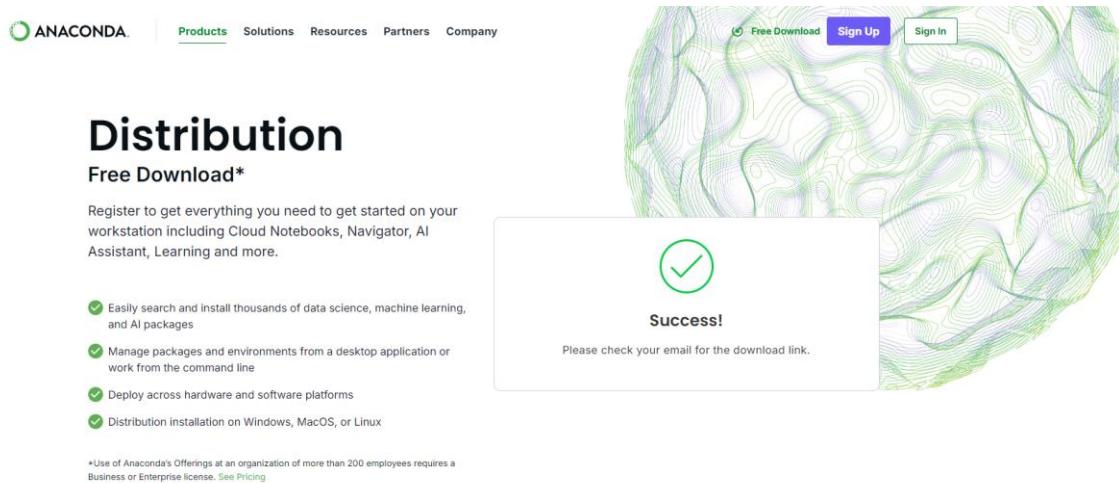
### Anaconda (Optional)

Although the Anaconda package is not required, it is a useful software that helps to manage packages, runtime environments, is equipped with scientific packages for the type of work conducted in this project and comes with Spyder which is Python editor.

1. Navigate to the free distribution download signup page at <https://www.anaconda.com/download>.
2. Fill out the details shown in Figure A.4 and click submit. This will result in the page seen in Figure A.5.

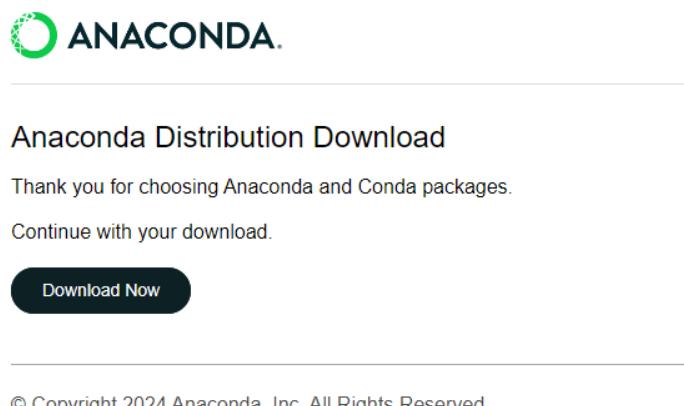


**Figure A.4:** Anaconda free distribution download signup page.



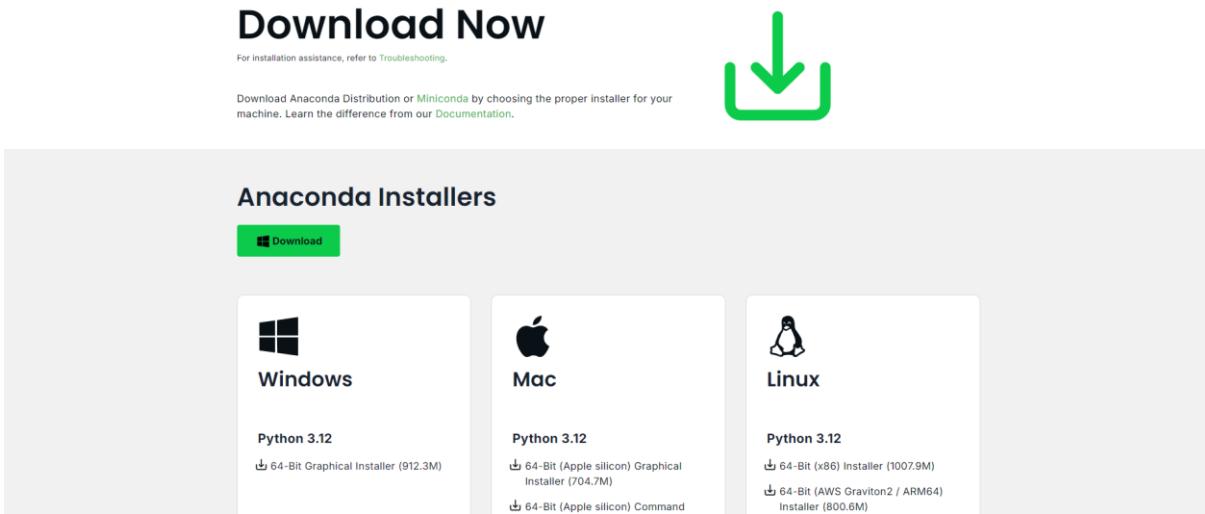
**Figure A.5:** Anaconda downloads page with the successful completion of email submission.

3. Click the download link that was sent via email, as shown in Figure A.6.



**Figure A.6:** Anaconda download link sent via email.

4. Select your operating system from the downloads page shown in Figure A.7.



**Figure A.7:** Anaconda download page with download links for different operating systems.

Install the correct version for your operating system. Once downloaded, run the executable file and walk through the install wizard. Default settings are recommended.

### Checking Available Solvers

Before installing additional solvers, the currently installed solvers can be checked by running the following script.

```
import pulp

solverlist = pulp.listSolvers(onlyAvailable=True)
print(solverlist)
```

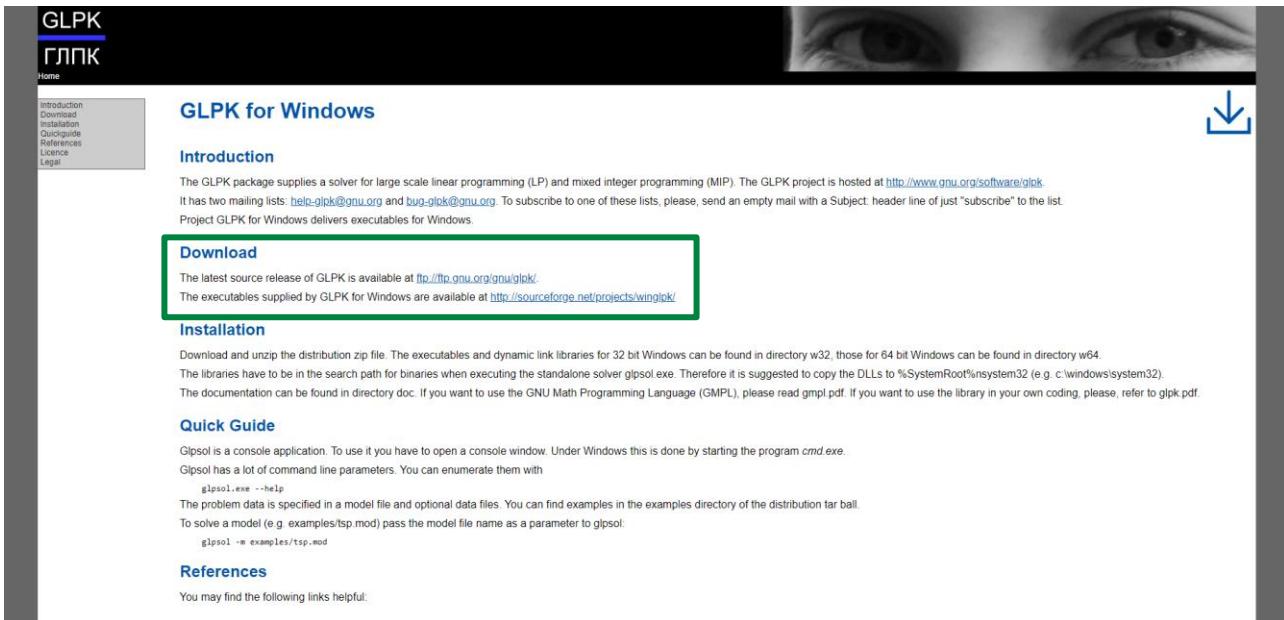
If no solvers have been installed on the device, as in the default case, the following output will be shown.

```
Available Solvers:  ['PULP_CBC_CMD']
```

### GLPK

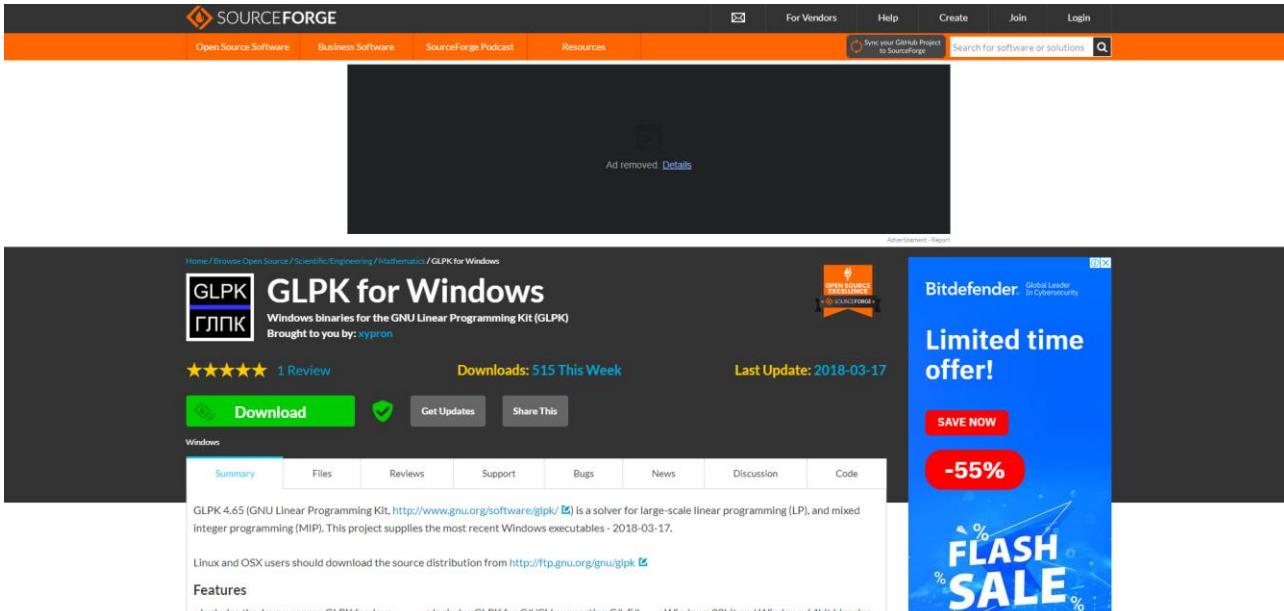
The installation method for GLPK differs depending on the operating system. Since the operating system used in this report is Windows, the following method will be for Windows. However, GLPK's homepage [151] has install guides for other operating systems.

1. Navigate to GLPK's Windows homepage at <https://winglpk.sourceforge.net/>.
2. Click on the executables for Windows link in the 'Download' section as in Figure A.8 below.



**Figure A.8:** GLPK for Windows homepage.

- Click the green download button, as shown in Figure A.9 to install the latest version of GLPK available for Windows.



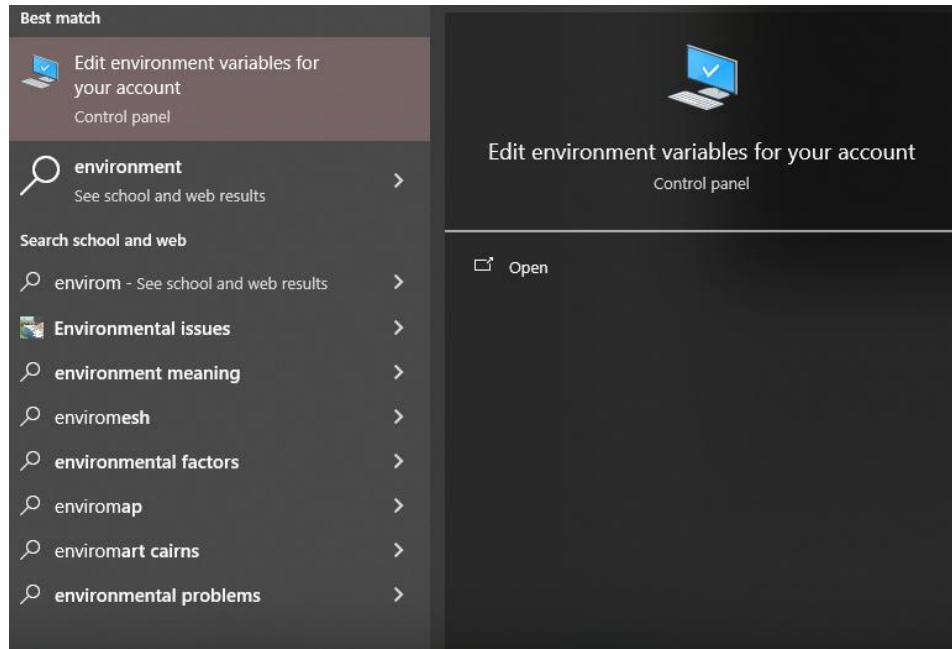
**Figure A.9:** GLPK for Windows downloads page.

- Navigate to your downloads folder and extract the files in the zip folder. The files depicted in Figure A.10 should be shown.

Name	Date modified	Type	Size
doc	28/09/2024 10:21 AM	File folder	
examples	28/09/2024 10:21 AM	File folder	
m4	28/09/2024 10:21 AM	File folder	
patch	28/09/2024 10:21 AM	File folder	
src	28/09/2024 10:21 AM	File folder	
swig	28/09/2024 10:21 AM	File folder	
swig-cli	28/09/2024 10:21 AM	File folder	
w32	28/09/2024 10:21 AM	File folder	
w64	28/09/2024 10:22 AM	File folder	
aclocal.m4	28/09/2024 10:21 AM	M4 File	35 KB
AUTHORS	28/09/2024 10:21 AM	File	2 KB
autogen.sh	28/09/2024 10:21 AM	SH File	1 KB
Build_WinGLPK.bat	28/09/2024 10:21 AM	Windows Batch File	5 KB
ChangeLog	28/09/2024 10:21 AM	File	134 KB
compile	28/09/2024 10:21 AM	File	8 KB
config.guess	28/09/2024 10:21 AM	GUESS File	44 KB
config.h.in	28/09/2024 10:21 AM	IN File	1 KB
config.sub	28/09/2024 10:21 AM	SUB File	35 KB
configure	28/09/2024 10:21 AM	File	404 KB
configure.ac	28/09/2024 10:21 AM	AC File	6 KB
COPYING	28/09/2024 10:21 AM	File	35 KB
depcomp	28/09/2024 10:21 AM	File	24 KB
Drvfile	28/09/2024 10:21 AM	File	105 KB

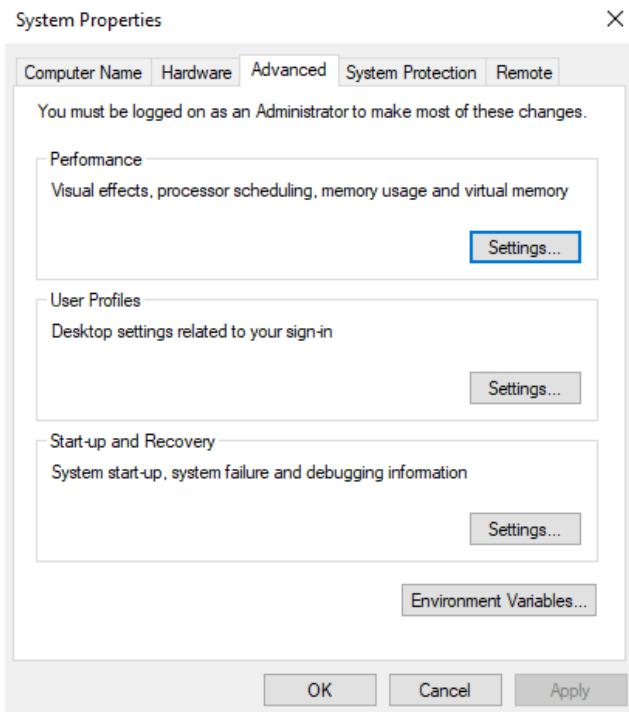
**Figure A.10:** Extracted files from the GLPK download.

5. Place the glpk-4.65 folder in a location of your choosing. For example, the C drive. Once the folder has been copied to the C drive, navigate to the ‘w64’ located in the glpk-4.65 folder. If you copied the folder into the C drive, the file location should be C:/glpk-4.65/w64. Copy this file location.
6. Open Windows Search and search for ‘Environment’ as shown in Figure A.11. Click the first option ‘Edit environment variables for your account’.

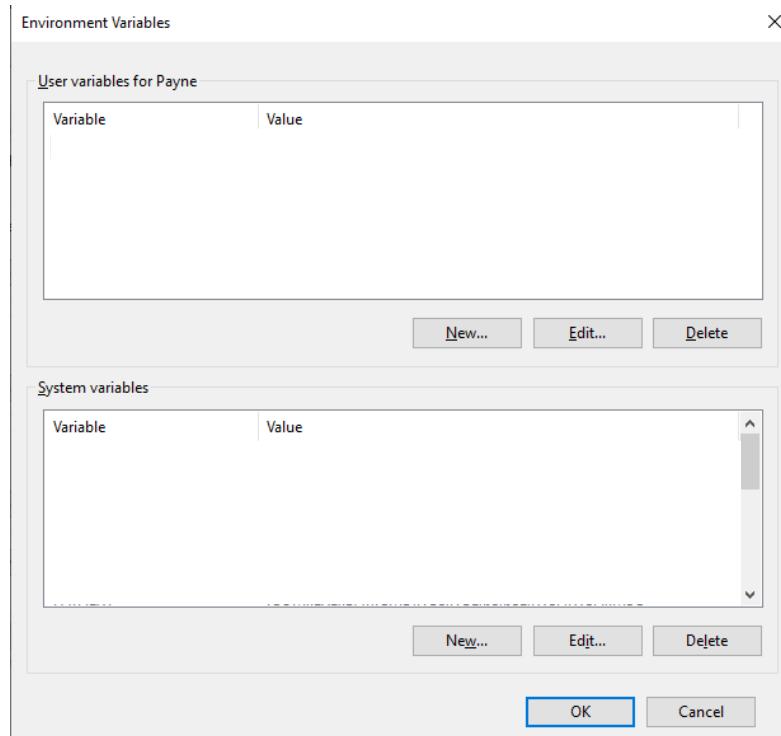


**Figure A.11:** Windows search for the environment variables.

7. Click on ‘Environment Variables...’ in Figure A.12. This will bring up the page shown in Figure A.13. Note that the actual variables are covered due to privacy reasons.

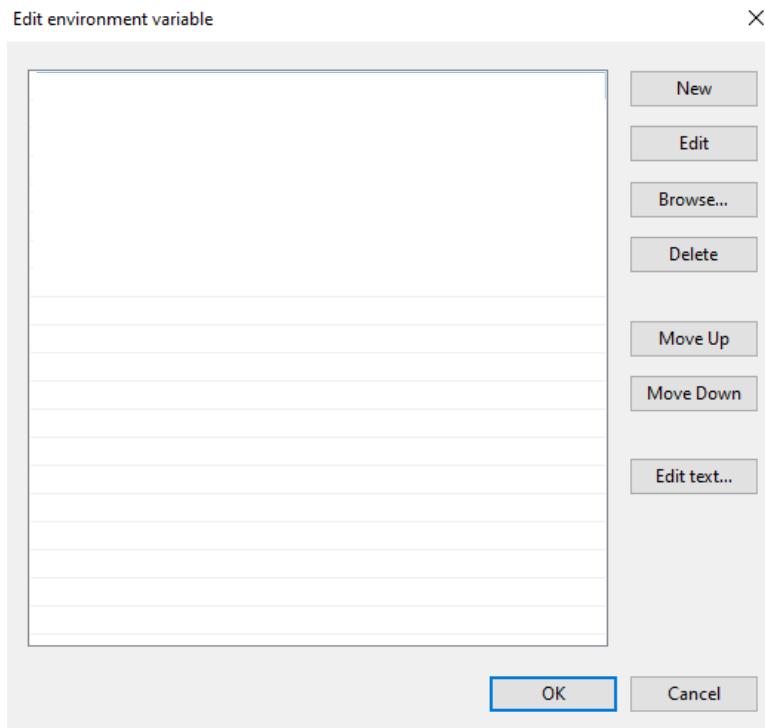


**Figure A.12:** Advanced system properties page.



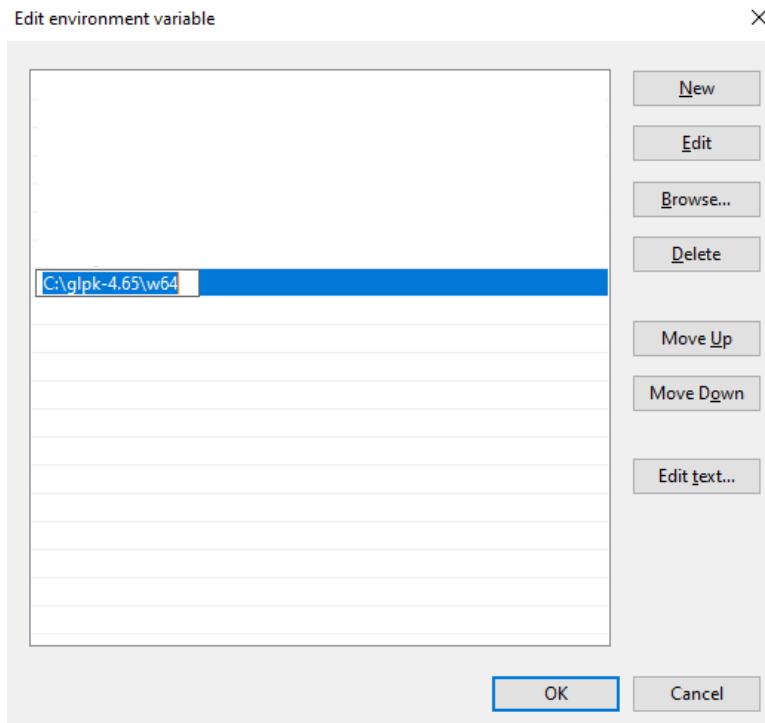
**Figure A.13:** Environment variables page which is split between user variables and system variables.

8. Click on the Path variable in the ‘System’ variable section. This will bring up the page shown in Figure A.14 below.



**Figure A.14:** System environment variable ‘Path’ page.

9. Click ‘New’ and paste the file directory of GLPK as shown in Figure A.15. Then click ‘OK’.
10. Click ‘OK’ on the other open menus and restart the coding editor.



**Figure A.15:** Adding the location of GLPK’s solver executable file as an environment variable.

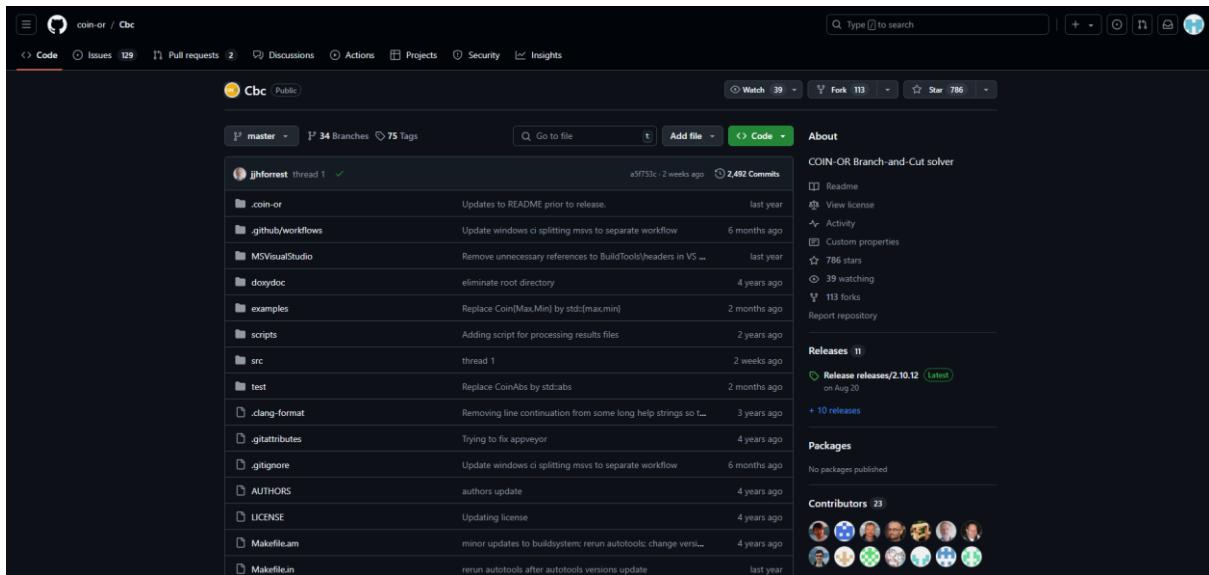
Upon rerunning the available solver script from before, ‘GLPK\_CMD’ should now come up as a solver option as shown below.

```
Available Solvers: [ 'GLPK_CMD' , 'PULP_CBC_CMD' ]
```

## COIN

The COIN-OR foundation has multiple solvers. The one of interest for this project is the COIN-OR CBC solver as it works with LP and MILP. The installation also comes with the CLP solver.

1. Navigate to the GitHub project directory found here: <https://github.com/coin-or/Cbc>.



**Figure A.16:** GitHub homepage of the COIN-OR CBC solver.

2. Scroll down to the README section and under the ‘Download’ heading, click on the binaries link as shown in Figure A.17. The page shown in Figure A.18 will then be displayed.

## DOWNLOAD

What follows is a quick start guide for obtaining or building Cbc on common platforms. More detailed information is available [here](#).

### Docker image

There is a Docker image that provides Cbc, as well as other projects in the [COIN-OR Optimization Suite](#) [here](#)

### Binaries

For newer releases, binaries will be made available as assets attached to releases in Github [here](#). Older binaries are archived as part of Cbc [here](#).

**Figure A.17:** Download section of the COIN-OR CBC solver homepage.

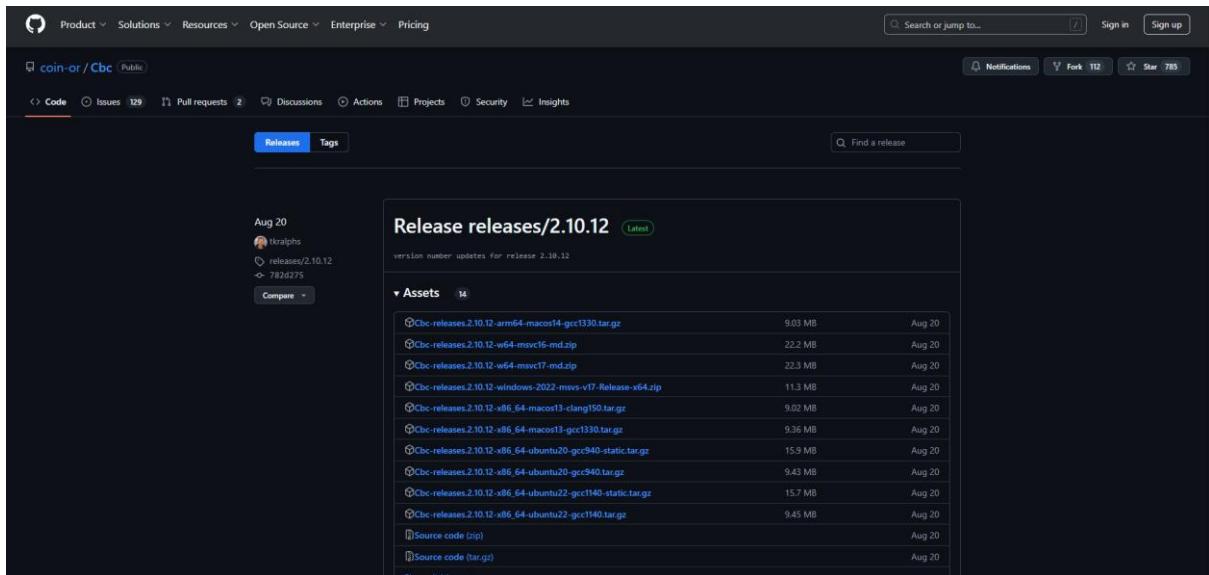


Figure A.18: COIN-OR CBC solver download links for different operating systems.

- Click on the appropriate download file. For this example, the operating system is Windows, and the installed Visual Studio version is 17 so “*Cbc-releases.2.10.12-w64-msvc17-md.zip*” is downloaded.

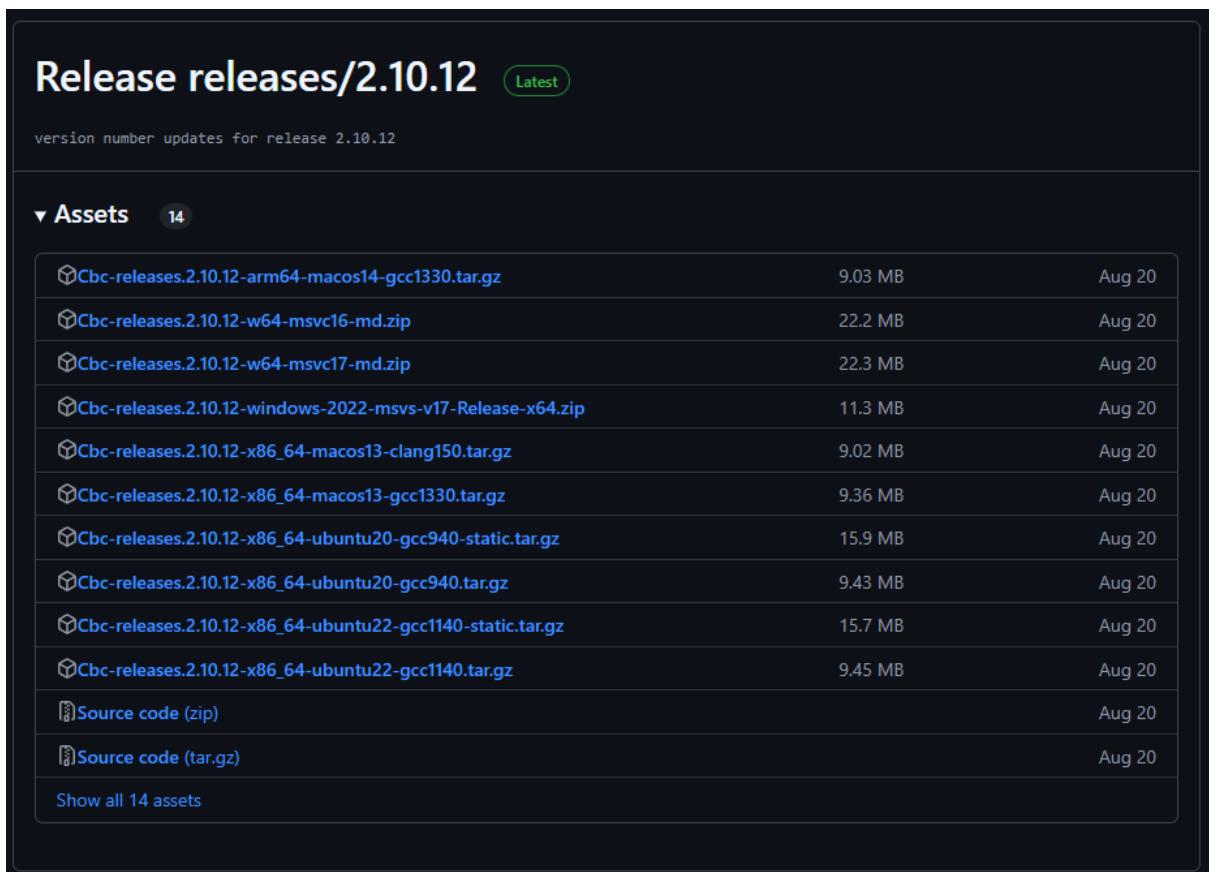


Figure A.19: Latest releases of the COIN-OR CBC solver.

4. Extract the contents of the downloaded zip file.
5. Copy the unzipped folder to the C drive or another location of your choice and rename the folder to “CBC” as shown in Figure A.20.

Name	Date modified	Type	Size
bin	1/10/2024 3:40 PM	File folder	
include	20/08/2024 4:53 PM	File folder	
lib	20/08/2024 5:07 PM	File folder	
share	20/08/2024 4:50 PM	File folder	
LICENSE	20/08/2024 5:07 PM	File	14 KB
README.md	20/08/2024 5:07 PM	MD File	29 KB

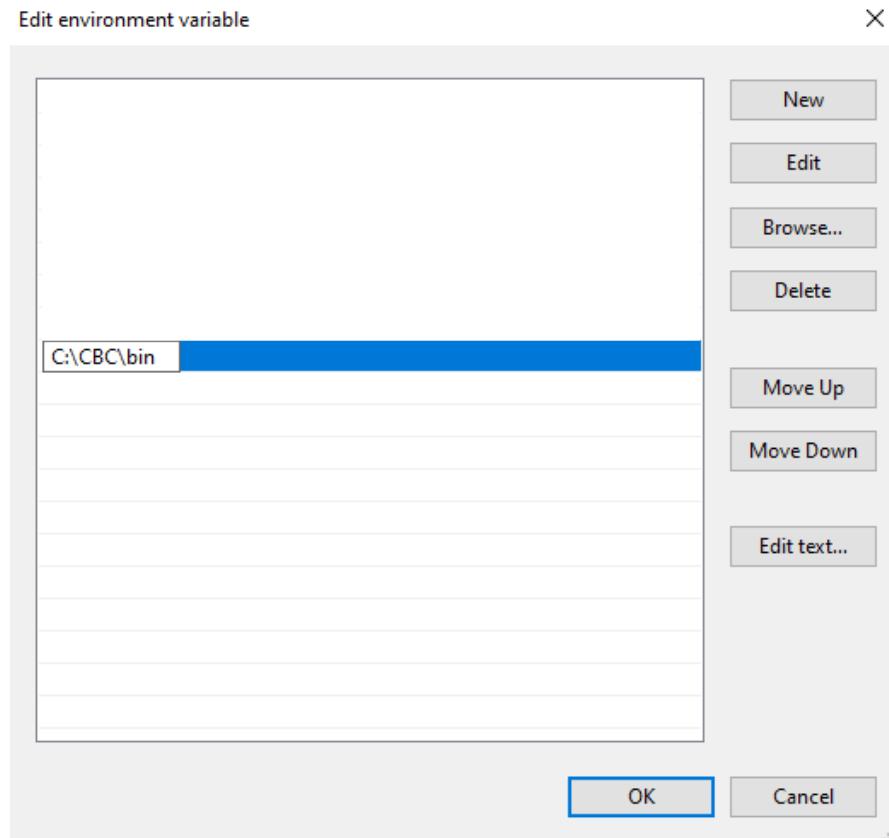
**Figure A.20:** Contents of the downloaded CBC solver zip file.

6. Navigate to the bin file located in the CBC folder which would be located at C:\CBC\bin where both the CBC and CLP solvers should be located. See Figure A.21.

Name	Date modified	Type	Size
cbc.exe	20/08/2024 5:07 PM	Application	3,885 KB
clp.exe	20/08/2024 4:58 PM	Application	2,088 KB

**Figure A.21:** Executable files inside the bin directory. ‘cbc.exe’ corresponds to the COIN-OR’s CBC solver and ‘clp.exe’ corresponds to COIN-OR’s CLP solver.

7. Copy the file directory and go back to the environment variables as shown before. Create a new system variable and paste the file location as shown in Figure A.22.



**Figure A.22:** Adding the location of COIN-OR's solvers executable files as an environment variable.

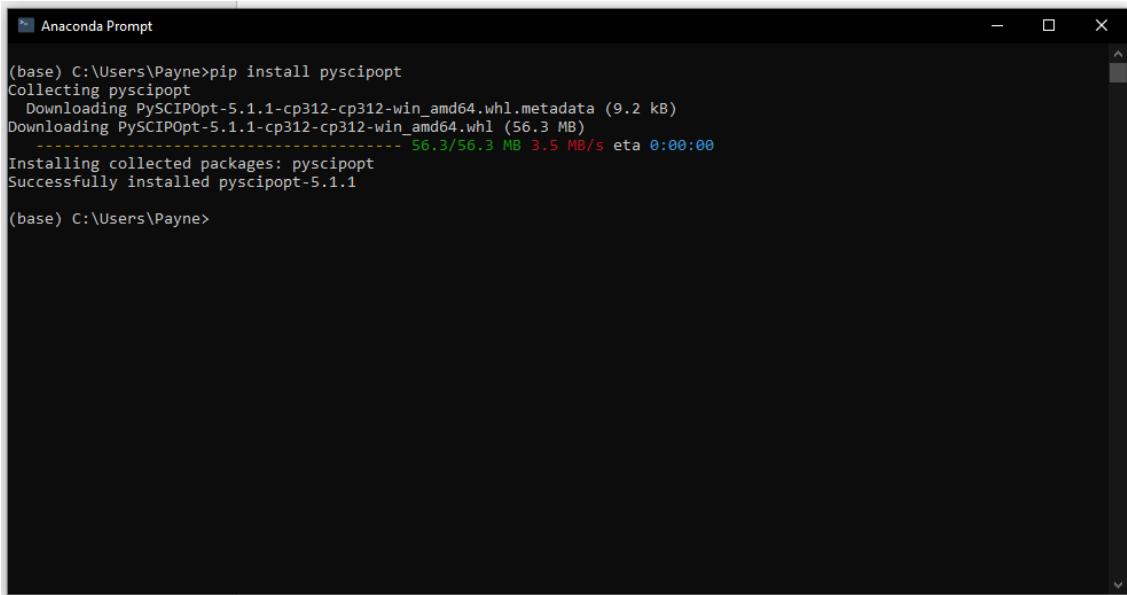
After successfully installing COIN-OR CLP and CBC, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: ['GLPK_CMD', 'PULP_CBC_CMD', 'COIN_CMD']
```

## SCIP

The SCIP Optimisation suite is one of the simpler solver installations and can be installed using a single command as shown below. The execution of this command is shown in Figure A.23. Documentation on the SCIP Optimisation suite can be found at <https://www.scipopt.org/> and <https://github.com/scipopt/PySCIOPt>.

```
pip install pypscipopt
```



```
Anaconda Prompt
(base) C:\Users\Payne>pip install pscipopt
Collecting pscipopt
  Downloading PySCIPOpt-5.1.1-cp312-cp312-win_amd64.whl.metadata (9.2 kB)
  Downloading PySCIPOpt-5.1.1-cp312-cp312-win_amd64.whl (56.3 MB)
    56.3/56.3 MB 3.5 MB/s eta 0:00:00
Installing collected packages: pscipopt
Successfully installed pscipopt-5.1.1
(base) C:\Users\Payne>
```

**Figure A.23:** Example execution of ‘`pip install pscipopt`’.

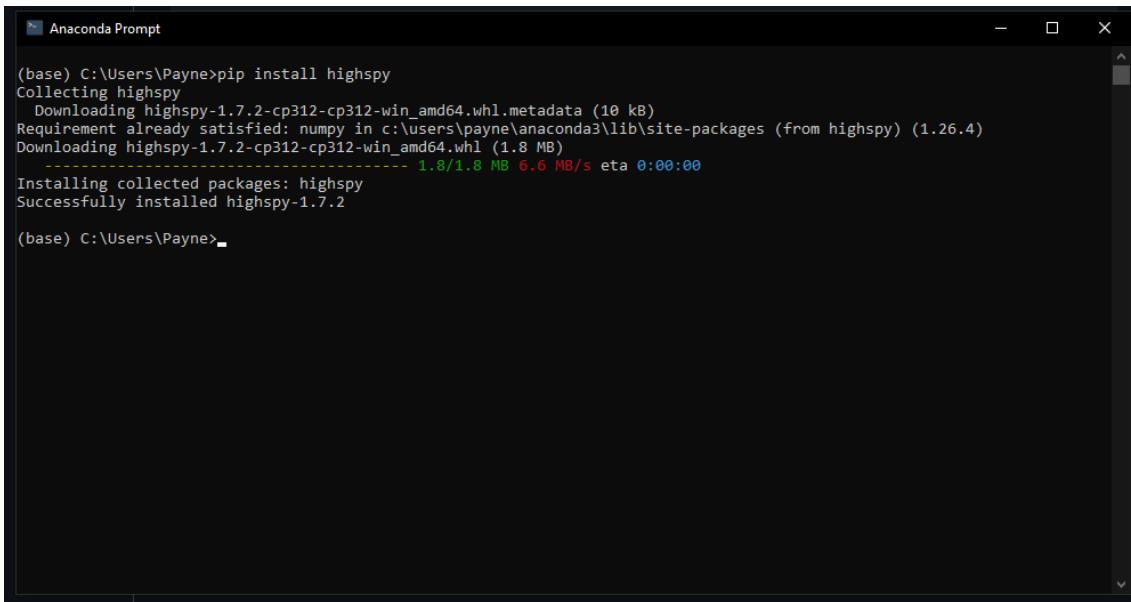
After successfully installing SCIP, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: [ 'GLPK_CMD', 'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY' ]
```

## HiGHS

Similar to SCIP, HiGHS can be installed with a single command as shown below. Pip can be used to install the HiGHS solver as shown below. The execution of this command is shown in Figure A.24. Documentation is provided at <https://highs.dev/> and <https://github.com/ERGO-Code/HiGHS>

```
pip install highspy
```



```
(base) C:\Users\Payne>pip install highspy
Collecting highspy
  Downloading highspy-1.7.2-cp312-cp312-win_amd64.whl.metadata (10 kB)
Requirement already satisfied: numpy in c:\users\payne\anaconda3\lib\site-packages (from highspy) (1.26.4)
  Downloading highspy-1.7.2-cp312-cp312-win_amd64.whl (1.8 MB)
    1.8/1.8 MB 6.6 MB/s eta 0:00:00
Installing collected packages: highspy
Successfully installed highspy-1.7.2
(base) C:\Users\Payne>
```

**Figure A.24:** Example execution of pip install highspy.

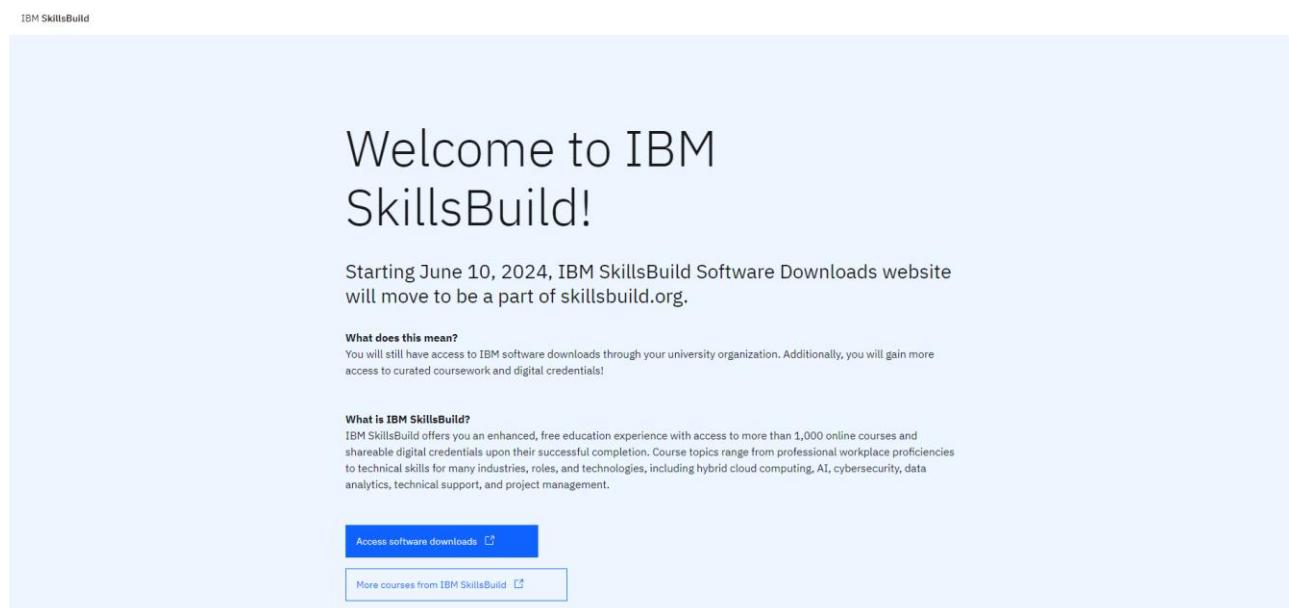
After successfully installing HiGHS, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: [ 'GLPK_CMD', 'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY', 'HiGHS' ]
```

## CPLEX

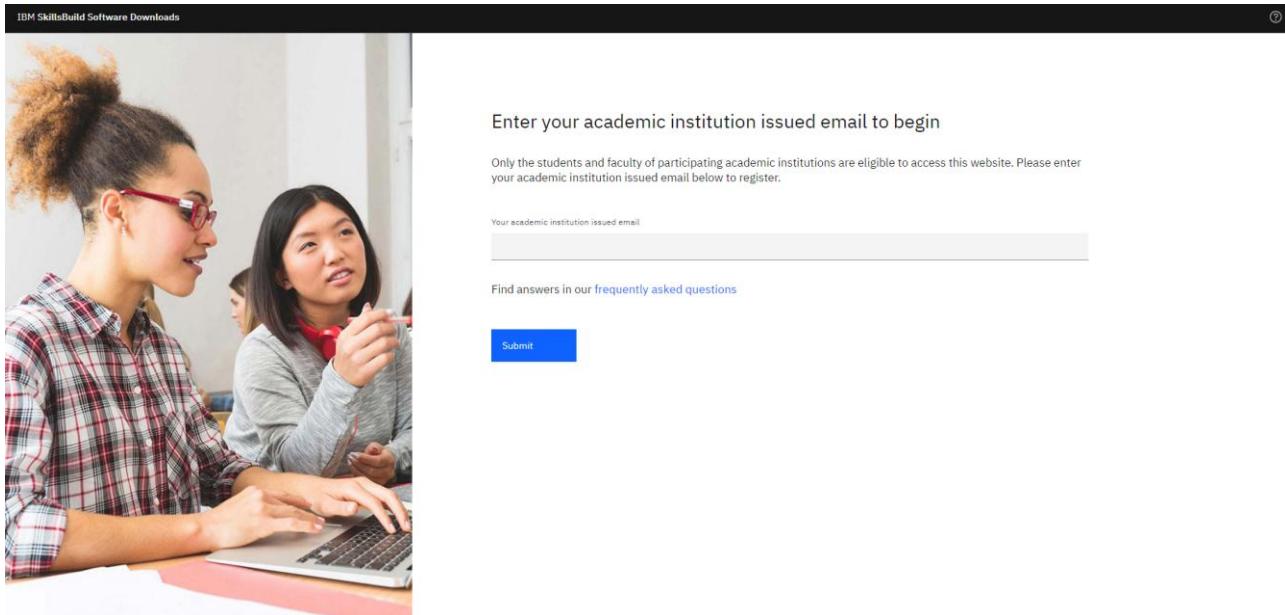
Since CPLEX is a commercial solver, there are more steps involved in installation. These are outlined below.

1. Head to the following webpage <https://www.ibm.com/academic/> as shown in Figure A.25.



**Figure A.25:** IBM's SkillsBuild software downloads webpage.

2. Click the ‘Access software downloads’ button and then fill out the details shown in the following figures.



**Figure A.26:** IBM’s academic institution email confirmation webpage.

A screenshot of the first page of the IBM registration process. It starts with a "Register below" section containing fields for "Academic institution issued email" (with "harrison.payne@student.adelaide.edu.au" entered), "Academic institution name" (University of Adelaide), and dropdown menus for "Role" (Choose role), "Title" (Title), "Current Degree" (Choose degree), and "Department" (Choose department). At the bottom is a checkbox for "Enroll me in the IBM badge program" with "Yes" checked.

**Figure A.27:** Page 1 of IBM’s registration process.

**IBM**

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Account information

Business email:  Email is required

Password:

First name:

Last name:

Country or region of residence:

**Next**

Additional information

Verify email

**Submit**

**Figure A.28:** Page 2 of IBM's registration process.

**IBM**

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Account information

Additional information

Company:  X | v

**Next**

Verify email

**Submit**

**Figure A.29:** Page 3 of IBM's registration.

- Enter the code received via email in the Figure A.30. After successful registration, you will be redirected to the webpage shown in Figure A.31.

The screenshot shows the 'IBM SkillsBuild Software Downloads' registration page. At the top, there's a section titled 'Harness the Power of IBM' with a brief description. Below this is a large grid of blue dots on a light background. To the right, there's a 'Verification token' field containing 'paycj001@mymail.unisa.edu.au'. Underneath it, a note says 'This code will expire in 30 minutes.' Further down, there's a 'Verification code' input field with a placeholder '7 digit code' and a red error icon. A message below it states 'A verification code is required in order to create an account.' There are also links for 'Log in' and 'Forgot password?'. On the right, there are sections for 'Account information', 'Additional information', and 'Verify email'. Under 'Verify email', there's a note about a 7-digit code being emailed to the user. At the bottom, there are checkboxes for 'Email' and 'I accept the product Terms and Conditions.', followed by a 'Submit' button.

**Figure A.30:** Email verification code entry form.

The screenshot shows the 'IBM SkillsBuild Software Downloads' page. On the left, a sidebar lists categories under 'All technologies': Artificial Intelligence, Capstone, Data Science, IBM Automation, IBM Cloud, IBM Engineering, IBM Security, IBM Z, Power Systems, Quantum Computing, and Red Hat Academy. Below this are links for 'Documentation' and 'Guest Lectures'. The main content area has a heading 'Explore all technologies' and a sub-section 'All technologies'. It features three cards: 'Artificial Intelligence' (blue background, green gear, brain icon), 'Capstone' (light blue background, blue gear, globe icon), and 'Data Science' (light blue background, blue gear, bar chart icon). Each card has a small arrow pointing to the right at the bottom.

**Figure A.31:** IBM SkillsBuild software downloads page.

- Click on the ‘Data Science’ page as shown in Figure A.32.
- Click on ‘ILOG CPLEX Optimization Studio’ and then click ‘Download’ on the popup page shown in Figure A.33. This will take you to the webpage shown in Figure A.34.

IBM SkillsBuild Software Downloads

All technologies  
Artificial Intelligence  
Capstone  
**Data Science**  
IBM Automation  
IBM Cloud  
IBM Engineering  
IBM Security  
IBM Z  
Power Systems  
Quantum Computing  
Red Hat Academy

Documentation  
Guest Lectures

## Data Science

Companies collect a plethora of information-but who can analyze and activate it? Data science experts can investigate trends, recommend actions, and help companies innovate. Build your expertise in this critical field with data science tools and softwares.



### Software

ILOG CPLEX Optimization Studio	SPSS Modeler Premium	Cognos Analytics on Cloud
Cognos Analytics	IBM DB2 Standard	Planning Analytics

**Figure A.32:** IBM's data science software packages.

### ILOG CPLEX Optimization Studio ↗

Analytical decision support toolkit for rapid development and deployment of optimization models using mathematical and constraint programming. It combines an integrated development environment with the powerful Optimization Programming Language and high-performance CPLEX and CP Optimizer solvers.

Download  
→

**Figure A.33:** ILOG CPLEX optimisation studio prompt to downloads page.

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## Search options

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[Part number](#)

### Find by part number

**Figure A.34:** ILOG CPLEX optimisation studio downloads page.

6. Scroll down until you reach then section shown in Figure A.35.
7. Select your operating system.

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violate the license terms applicable to the eAssembly. Your acceptance of the license terms applicable to the eAssembly is a precondition to your downloading and using the eAssembly.

Overview

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Related Links

<input type="checkbox"/>	<a href="#">Image</a>	<a href="#">Description</a>	<a href="#">Date posted</a>	<a href="#">Size (MB)</a>
<input type="checkbox"/>	M08SYML	IBM ILOG CPLEX Optimization Studio V22.1.1 Quick Start Guide	12/9/2022	2,639,480
<input type="checkbox"/>	<a href="#">View details</a>	<a href="#">License agreement</a>	<a href="#">Download estimate</a>	eAssembly →
<input checked="" type="checkbox"/>	M08SZML	IBM ILOG CPLEX Optimization Studio V22.1.1 for Windows x86-64	12/9/2022	736,943,230
<input checked="" type="checkbox"/>	<a href="#">View details</a>	<a href="#">License agreement</a>	<a href="#">Download estimate</a>	eAssembly →
<input type="checkbox"/>	M08T0ML	IBM ILOG CPLEX Optimization Studio V22.1.1 for Linux x86-64	12/9/2022	654,750,460
<input type="checkbox"/>	<a href="#">View details</a>	<a href="#">License agreement</a>	<a href="#">Download estimate</a>	eAssembly →
<input type="checkbox"/>	M08T1ML	IBM ILOG CPLEX Optimization Studio V22.1.1 for Linux on System i/p	12/9/2022	270,504,448
<input type="checkbox"/>	<a href="#">View details</a>	<a href="#">License agreement</a>	<a href="#">Download estimate</a>	eAssembly →
<input type="checkbox"/>	M08T2ML	IBM ILOG CPLEX Optimization Studio V22.1.1 for OSX	12/9/2022	802,059,010
<input type="checkbox"/>	<a href="#">View details</a>	<a href="#">License agreement</a>	<a href="#">Download estimate</a>	eAssembly →
<input type="checkbox"/>	M08WXML	IBM ILOG CPLEX Optimization Studio V22.1.1 for OSX ARM64	12/9/2022	776,439,940

**Figure A.35:** Operating system download options for CPLEX.

8. Scroll down and agree to the terms and conditions.
9. Click the ‘Download now’ button shown in Figure A.36.

IBM

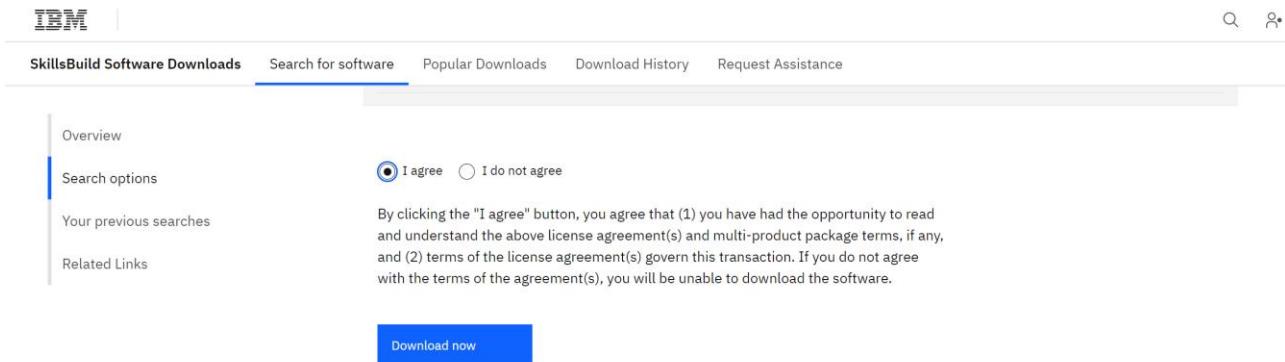
SkillsBuild Software Downloads Search for software Popular Downloads Download History Request Assistance

Overview  
Search options  
Your previous searches  
Related Links

I agree  I do not agree

By clicking the "I agree" button, you agree that (1) you have had the opportunity to read and understand the above license agreement(s) and multi-product package terms, if any, and (2) terms of the license agreement(s) govern this transaction. If you do not agree with the terms of the agreement(s), you will be unable to download the software.

Download now



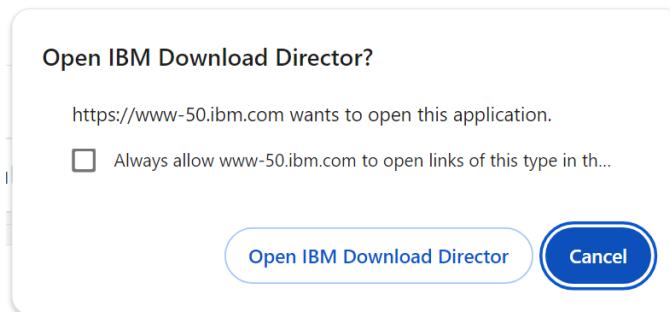
### Your previous searches

Select one of the options below

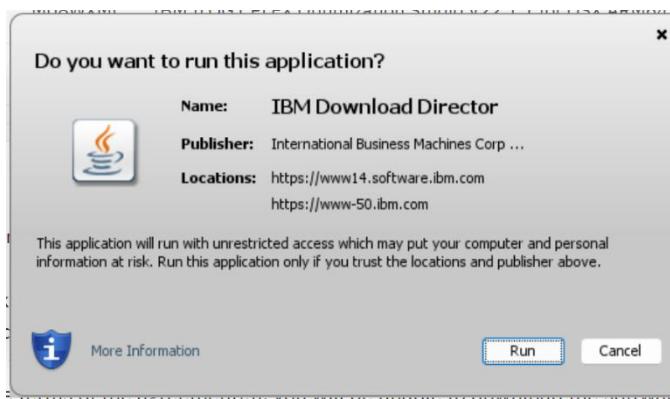
- Find by text
- Find by brand
- Find by part number

**Figure A.36:** CPLEX terms and conditions.

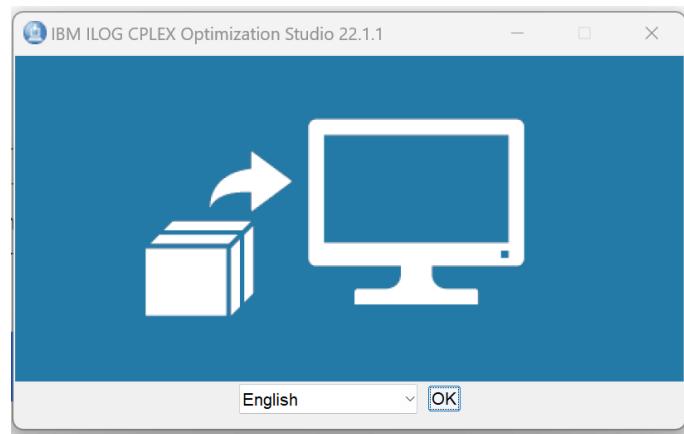
10. Follow the prompts outlined in the subsequent figures.



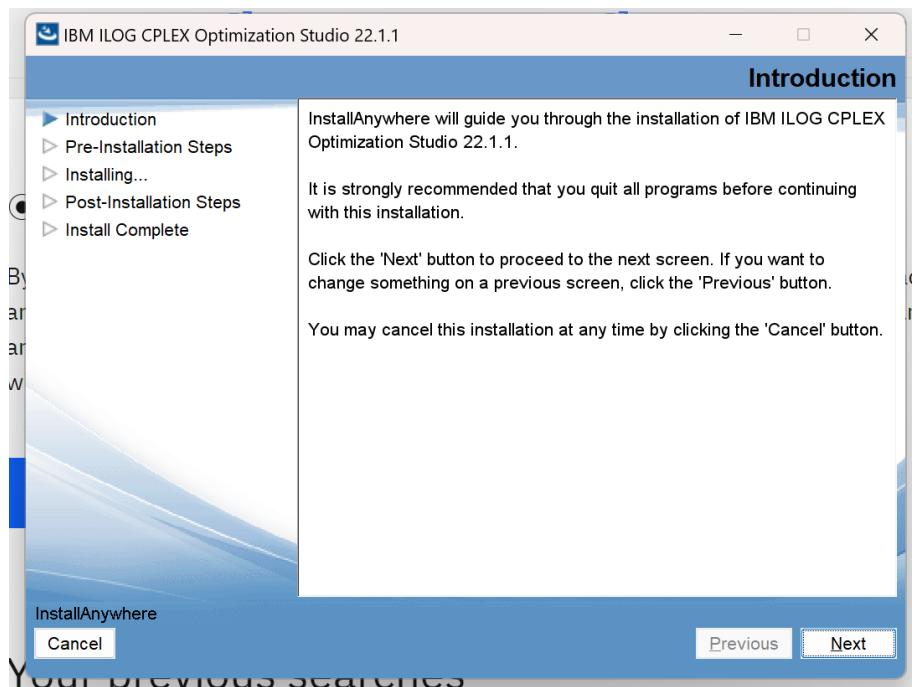
**Figure A.37:** IBM download direction launch prompt.



**Figure A.38:** IBM download director execute prompt.



**Figure A.39:** CPLEX optimisation studio language setup.



**Figure A.40:** Page 1 of CPLEX's setup wizard.

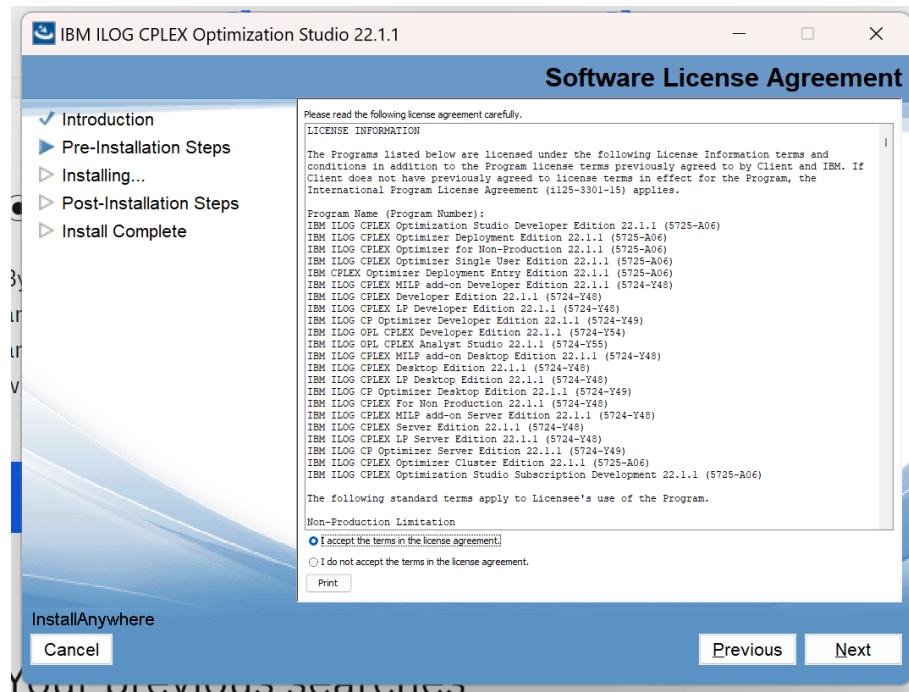


Figure A.41: Page 2 of CPLEX's setup wizard.

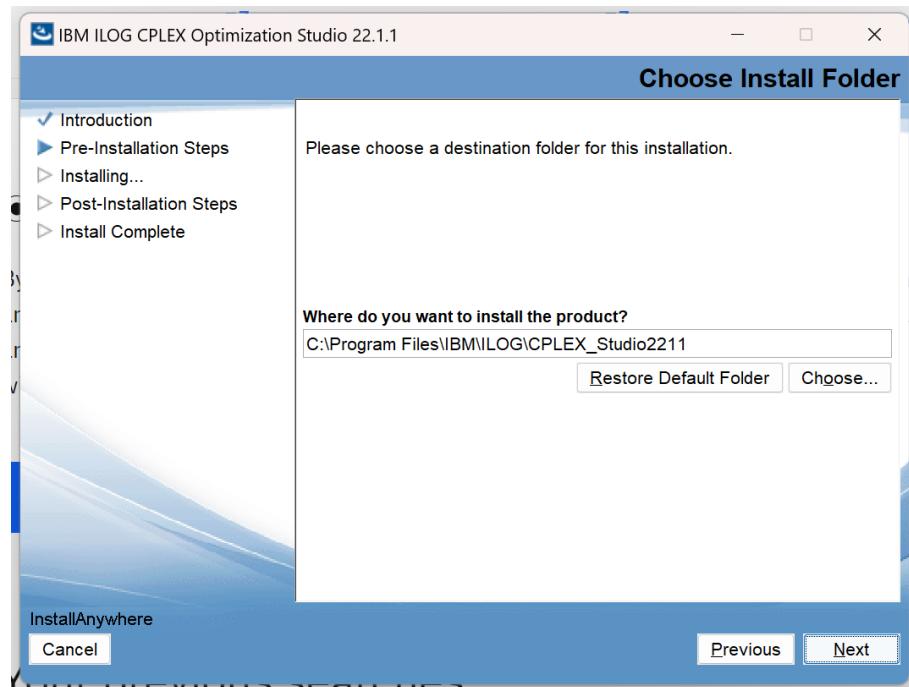


Figure A.42: Page 3 of CPLEX's setup wizard.

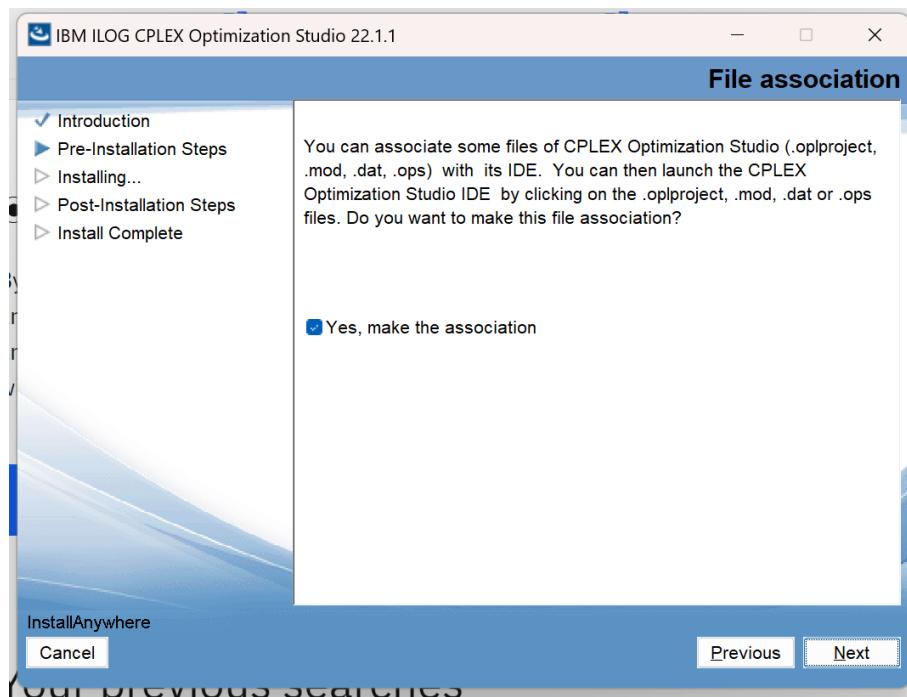


Figure A.43: Page 4 of CPLEX's setup wizard.

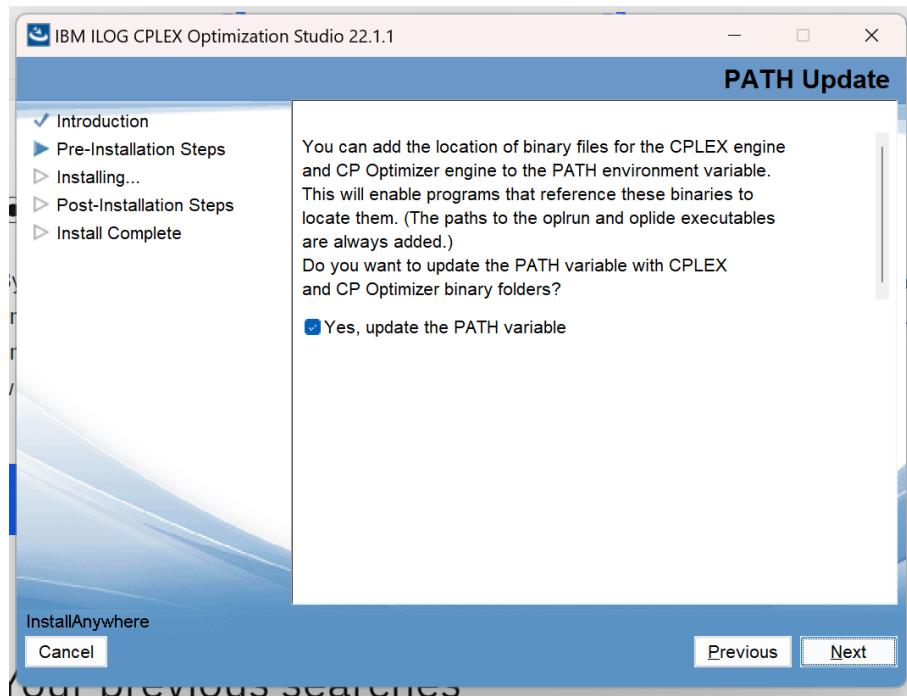


Figure A.44: Page 5 of CPLEX's setup wizard.

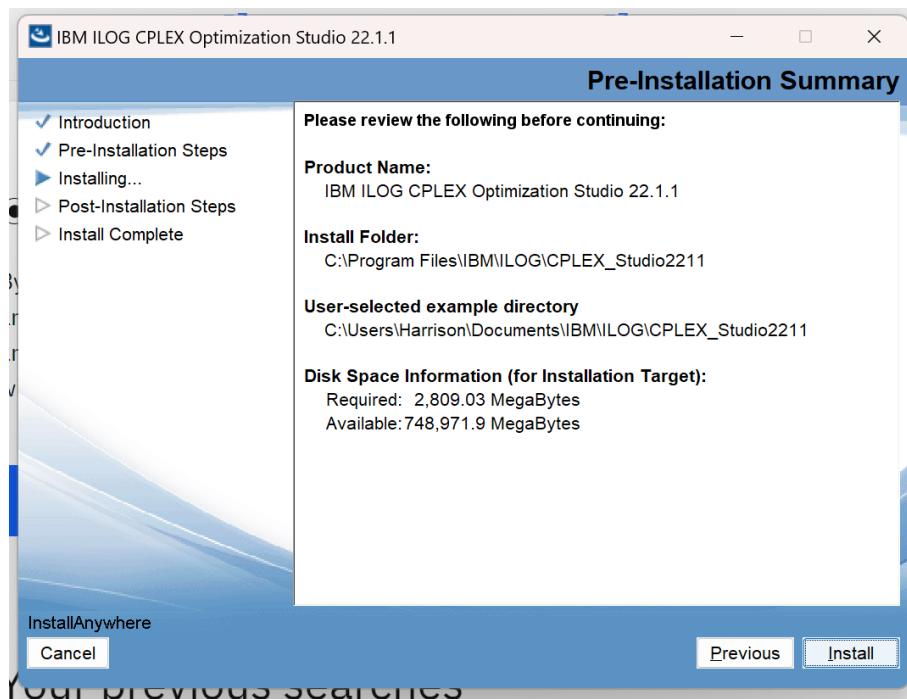


Figure A.45: Page 6 of CPLEX's setup wizard.

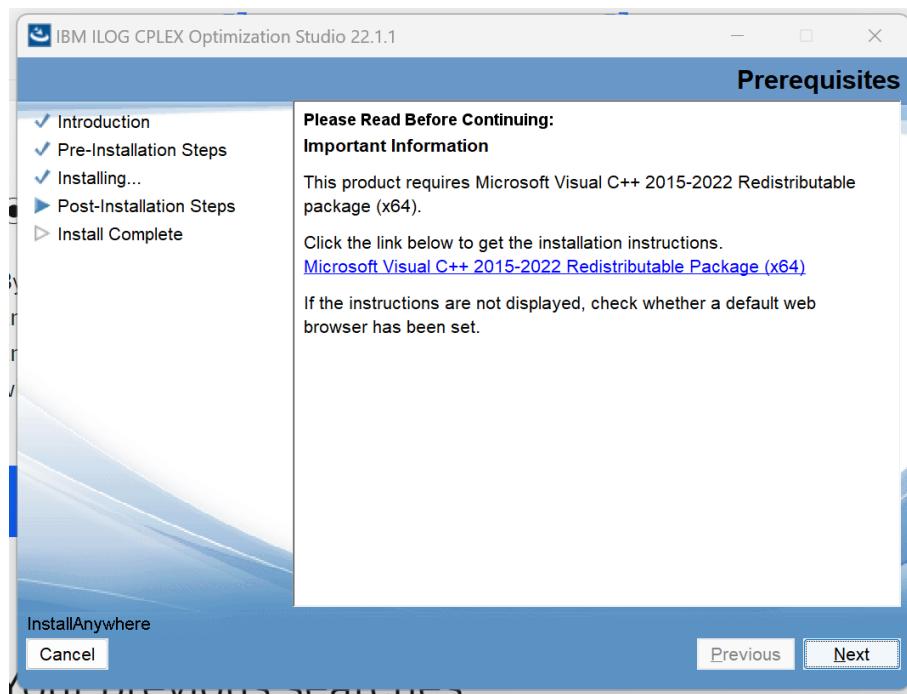
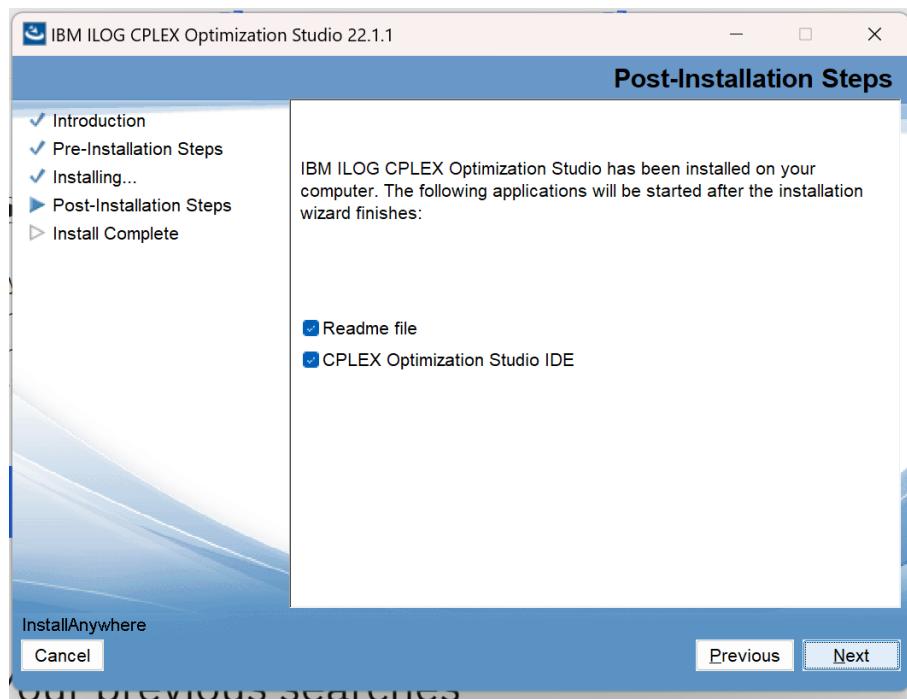
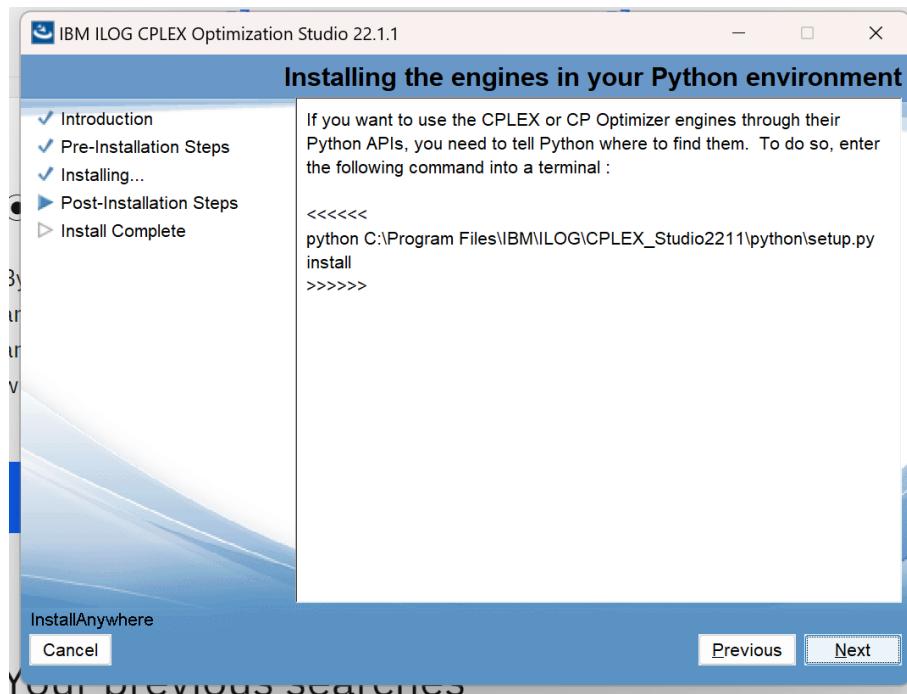


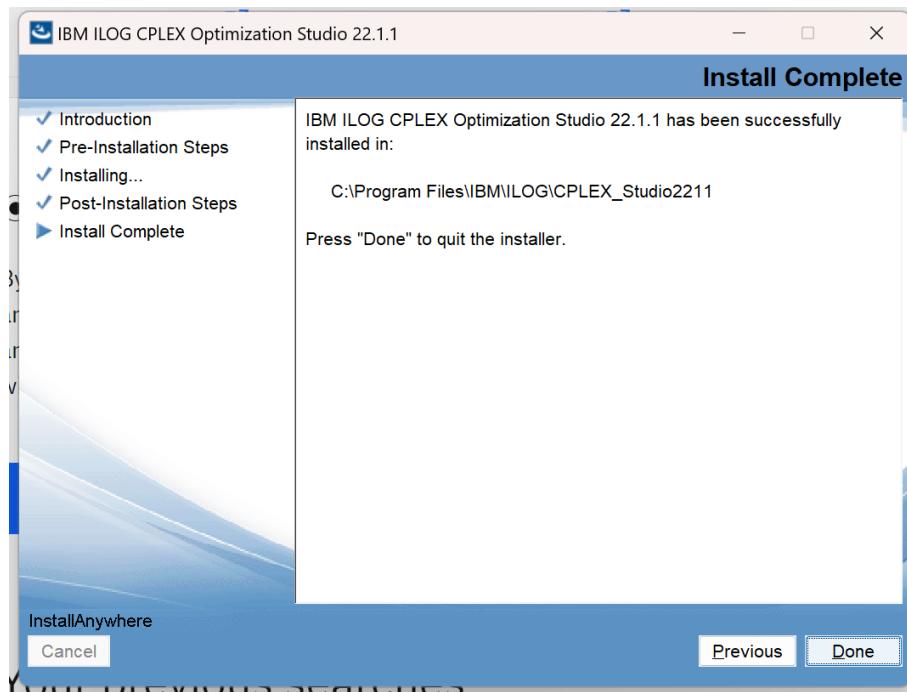
Figure A.46: Page 7 of CPLEX's setup wizard.



**Figure A.47:** Page 8 of CPLEX's setup wizard.



**Figure A.48:** Page 9 of CPLEX's setup wizard.



**Figure A.49:** Page 10 of CPLEX's setup wizard.

After successfully installing CPLEX, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: ['GLPK_CMD', 'CPLEX_CMD', 'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY',  
'HiGHS']
```

## Gurobi

The installation guide for the Gurobi solver is outlined in the steps below.

1. Navigate to Gurobi's registration webpage: <https://portal.gurobi.com/iam/register/>.
2. Fill out the information required in the three registration pages shown in Figure A.50, Figure A.51 and Figure A.52 below.



## Register

1      2      3

Contact

Your

Submit

Email \*

|

Please use your company or university email address

First Name \*

Last Name \*

Country/Region \*

Select... ▾

NEXT

Have an account? [Sign in now](#)

**Figure A.50:** Page 1 of Gurobi's registration process.



## Register

✓      2      3

Contact

Your

Submit

Are you a Commercial, Academic, or NGO/Non-Profit user? \*

COMMERCIAL

ACADEMIC

NGO/NON-PROFIT

University \*

Select or enter a university...

Please select or manually enter your university

Academic Position \*

Select... ▾

BACK

NEXT

Have an account? [Sign in now](#)

**Figure A.51:** Page 2 of Gurobi's registration process.



## Register

Contact      Your Work      Submit

Password \*

>Password must be at least 12 characters long, contain at least one upper case, lower case, digit and symbol

- The information you provide to us will be used in accordance with the terms of our [Privacy Policy](#).
- I agree to receive relevant marketing content on webinars, new product releases, and invitations to Gurobi events.

BACK

SUBMIT

Have an account? [Sign in now](#)

**Figure A.52:** Page 3 of Gurobi's registration process3.

3. Sign into your newly created Gurobi account and the homepage shown in Figure A.53 should be loaded.

The screenshot shows the Gurobi User Portal homepage. At the top, there is a navigation bar with the Gurobi Optimization logo, a "User Portal" link, and user profile information for "Harrison Payne". On the left, a vertical sidebar menu includes "Home", "Licenses", and "News". The main content area features three cards: "Welcome Harrison" (Account Information), "Licenses" (with options to review current licenses, open WLS manager, request academic license, and transfer license), and "Cloud" (with options to open Cloud Manager, review cloud licenses, and check what's new).

Welcome Harrison

Account Information

- > Review your profile information
- > Change your password
- > Set up two-factor authentication

Licenses

- > Review your current licenses
- > Open the WLS manager
- > Request a free academic license
- > Request a license transfer

Cloud

- > Open the Cloud Manager
- > Review your cloud licenses
- > What's New

**Figure A.53:** Gurobi account homepage.

- Click on the licenses tab → request as shown in Figure A.54.

The screenshot shows the Gurobi User Portal with the 'Licenses' tab selected. The 'ACADEMIC' tab is highlighted. There are four main sections for academic users:

- WLS Academic:** Runs Gurobi Optimizer where you want, across regular machines or container environments (Docker, Kubernetes...) with floating capability. Requirements: Runs on machines and containers, Requires Gurobi v10 or later, Requires an internet connection during usage, Valid for 90 days, Can be extended as long as you maintain eligibility. Button: GENERATE NOW!
- Named-User Academic:** Get a free, unlimited-use Gurobi Optimizer license for a single person, on a single machine. Requirements: Runs on a single machine only, Supports any Gurobi versions, Requires an internet connection for installation, Valid for one year, New licenses can be generated as long as you maintain eligibility. Button: GENERATE NOW!
- Take Gurobi With You:** Through the Take Gurobi With You (TGWY) program, you can continue to get free, unrestricted access to Gurobi after graduation. This means you can bring the speed, scope, and problem-solving power of optimization with you into the workplace, using a tool you already know. Button: APPLY NOW!
- Educational Institution Site:** Share Gurobi with multiple users in your academic departments, schools, and classrooms by running Gurobi on your university's local-area network, at no cost to you or your institution. To get started, your institution's network administrator will need to visit our Help Center and request an Academic Site License. Button: SUBMIT REQUEST

**Figure A.54:** Gurobi account license request page.

- Click on the named-user academic license ‘Generate Now!’ button and the page shown in Figure A.55 will be presented.
- Click ‘Confirm Request’ to begin the license activation. Note that the license may not be generated if the Wi-Fi network is not at the university.

The screenshot shows a pop-up window titled 'Create Named-User Academic License'. It contains the following text:

An academic license may only be used by a faculty member, a student, or a member of the research or administrative staffs of a degree-granting academic institution. The code may be used only for research and educational purposes. Access for commercial purposes is forbidden.

The license must not be shared with other users or stored in public repositories.

In order to create or extend the academic license, your computer must be connected to a recognized academic institution network when the request is made.

Check here to indicate that you have read and agree to the terms of the [End User License Agreement](#)

At the bottom right of the pop-up are 'CANCEL' and 'CONFIRM REQUEST' buttons.

**Figure A.55:** Pop up for a request of Gurobi’s Named-User Academic license.

7. Navigate to the following page <https://www.gurobi.com/downloads/gurobi-software/> after the license has been activated.
8. Scroll down and install the Gurobi Optimiser version suitable for your operating system as shown in Figure A.56.

The screenshot shows the Gurobi Optimization website's download page. At the top, there is a navigation bar with links for Solutions, Resources, Partners, Academic, Company, a Free Trial button, and a search icon. Below the navigation bar, the page title is "Current Versions". Under "Gurobi Optimizer", there is a table for version v11.0.3. The table has three columns: "v11.0.3", "Installer", and "md5 Checksum". The rows list various operating systems and their corresponding installer files and md5 checksums:

v11.0.3	Installer	md5 Checksum
x64 Windows	Gurobi11.0.3-win64.msi	Gurobi11.0.3-win64.msi.md5
x64 Linux	gurobi11.0.3_linux64.tar.gz	gurobi11.0.3_linux64.tar.gz.md5
macOS Universal2	gurobi11.0.3_macos_universal2.pkg	gurobi11.0.3_macos_universal2.pkg.md5
x64 AIX	gurobi11.0.3_power64.tar.gz	gurobi11.0.3_power64.tar.gz.md5
arm64 Linux	gurobi11.0.3_armlinux64.tar.gz	gurobi11.0.3_armlinux64.tar.gz.md5

At the bottom of the page, there is a section for "Gurobi Remote Services" with a note about optional cluster support.

**Figure A.56:** Gurobi solver downloads page.

9. Complete the setup wizard shown in the following figures.



**Figure A.57:** Page 1 of Gurobi's setup wizard.

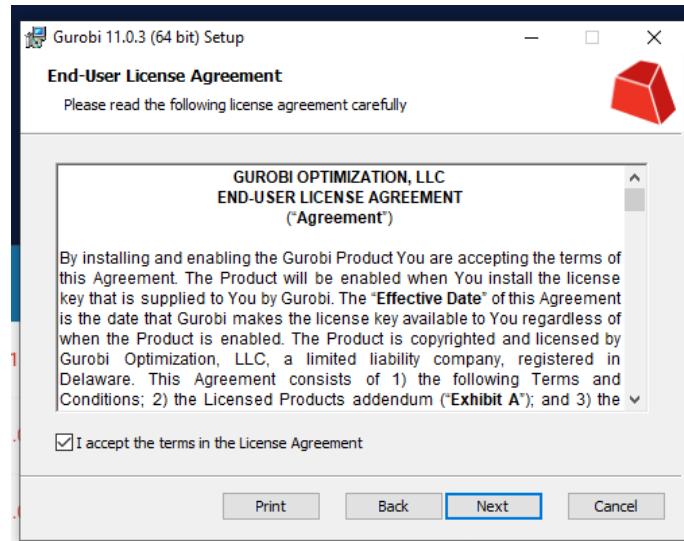


Figure A.58: Page 2 of Gurobi's setup wizard.

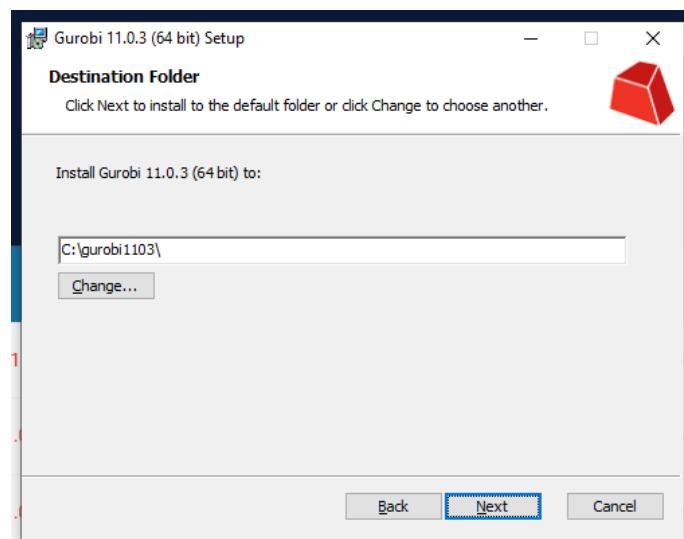


Figure A.59: Page 3 of Gurobi's setup wizard.

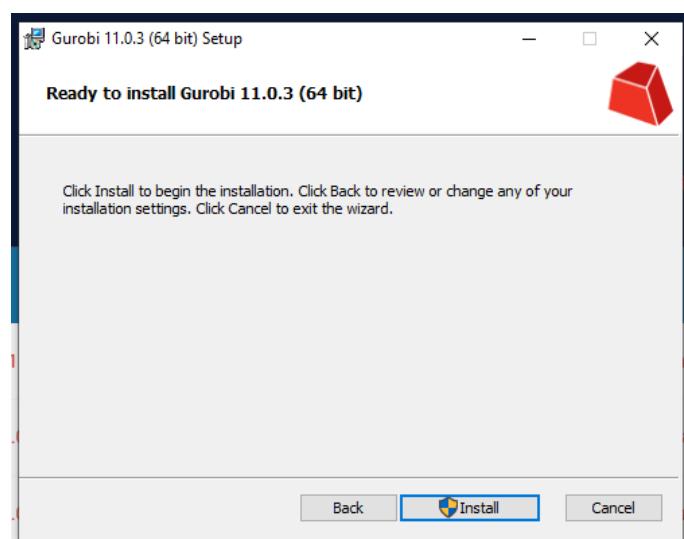
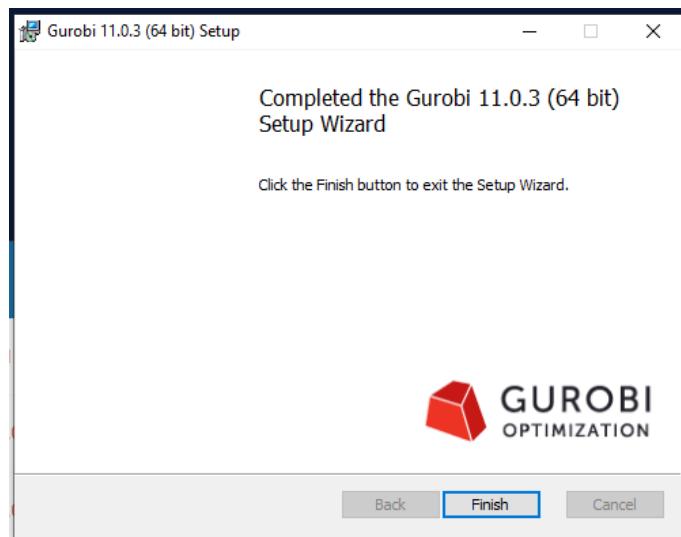


Figure A.60: Page 4 of Gurobi's setup wizard.



**Figure A.61:** Page 5 of Gurobi's setup wizard.

10. Restart your computer if required.
11. Login to Gurobi once your computer has restarted.
12. Click on the licenses tab.
13. Click on the icon shown in Figure A.62.

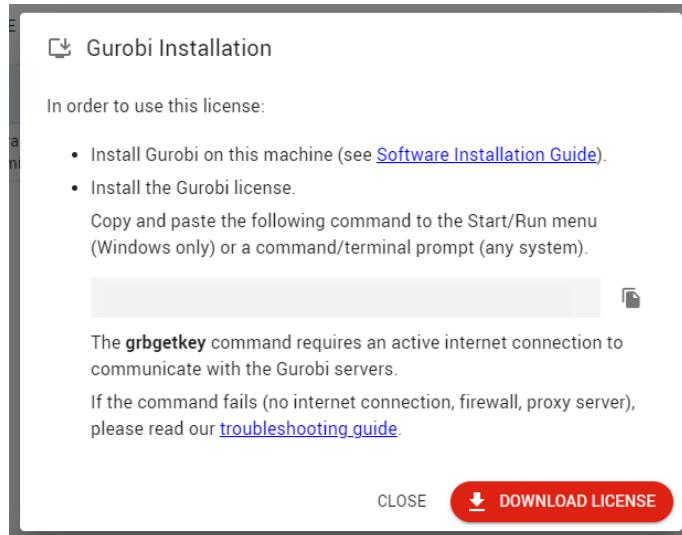
A screenshot of the Gurobi User Portal. The top navigation bar includes links for Documentation, Downloads, Support, and a user profile for Harrison Payne. On the left, a sidebar menu has "Licenses" selected. The main content area is titled "Licenses (2)". It shows two entries in a table:

ID	TYPE	PURPOSE	CREATED AT (GMT+9:30)	EXPIRATION (GMT+9:30)	CATEGORY	SUMMARY
2544177	Free Academic	Trial	Aug 16, 2024	Aug 17, 2025	Regular	version 11, installed on SILVERTONLAPTOP
2544168	WLS Compute Server	Temporary Academic	Aug 16, 2024	Nov 15, 2024	WLS	compute server, 2 sessions

Below the table, there are tabs for INFO, NOTIFICATION SETTINGS, TYPE, VALIDITY, LIMITS, and HOST. The INFO tab is active, showing the ID 2544177. There are also "Show installation instructions for this license" and "Edit" buttons.

**Figure A.62:** Gurobi user licenses page.

14. Copy the command shown in Figure A.63. Due to privacy reasons, the license code has been blurred.



**Figure A.63:** Guide to activating a Gurobi license.

15. Launch a command terminal and paste the command copied from Figure A.63. Note that your computer will need to be connected to the university Wi-Fi for this to work.

After successfully installing Gurobi, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: ['GLPK_CMD', 'CPLEX_CMD', 'GUROBI_CMD', 'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY', 'HiGHS']
```

The Python interface to the Gurobi library can simply be installed using pip as shown below.

```
pip install gurobipy
```

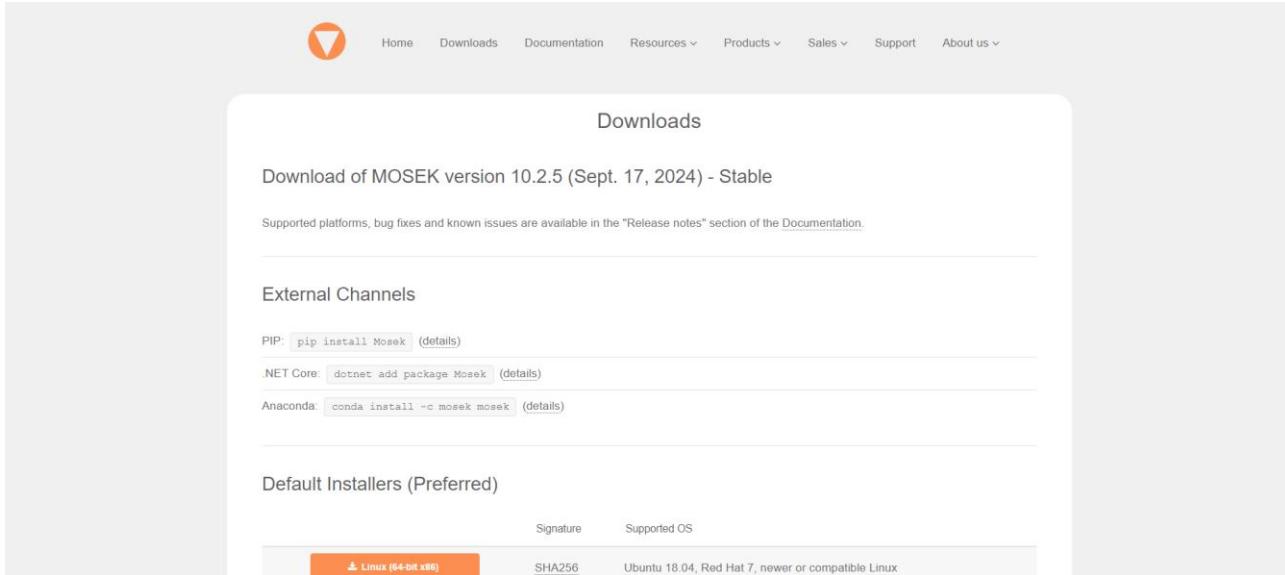
This interface is distinguished from the command line interface (CMD) version as it appears as 'GUROBI' in the list of available solvers as shown below.

```
Available Solvers: ['GLPK_CMD', 'CPLEX_CMD', 'GUROBI', 'GUROBI_CMD', 'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY', 'HiGHS']
```

## Mosek

The following is a guide on how to install and register a license for the Mosek.

1. Head to the Mosek downloads page <https://www.mosek.com/downloads/> as shown in Figure A.64.



**Figure A.64:** Mosek downloads page.

2. Scroll down to the ‘Default Installers (Preferred)’ section as shown in Figure A.65. Note that Mosek can be installed in a number of ways as outlined on the webpage, however, this guide will walk through the preferred method.
3. Click on the operating system relevant to you to download the installer.

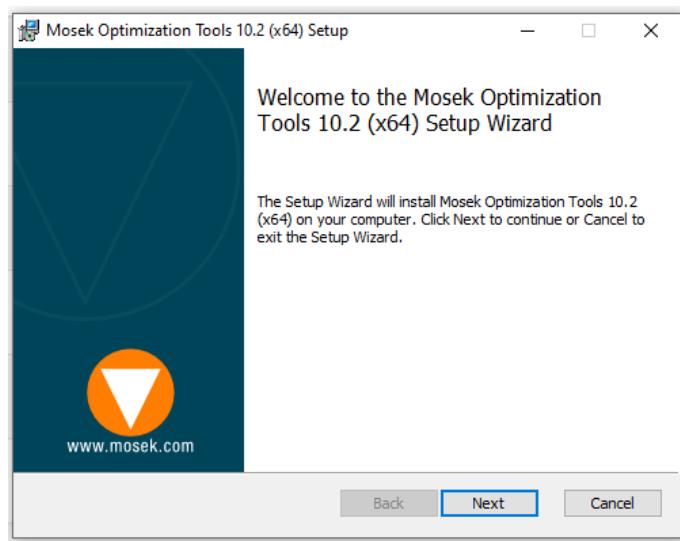
### Default Installers (Preferred)

	Signature	Supported OS
<a href="#">Linux (64-bit x86)</a>	SHA256	Ubuntu 18.04, Red Hat 7, newer or compatible Linux
<a href="#">Linux (64-bit ARM)</a>	SHA256	Ubuntu 20.04, newer or compatible Linux
<a href="#">Mac (64-bit x86)</a>	SHA256	macOS 10.15 or newer
<a href="#">Mac (64-bit ARM)</a>	SHA256	macOS 11 or newer
<a href="#">NuGet (Any Platform)</a>	SHA256	.NET Standard 2.0
<a href="#">Windows (64-bit x86)</a>	SHA256	Windows 10, Server 2016 or newer
<a href="#">Windows (32-bit x86)</a>	SHA256	Windows 10, Server 2016 or newer

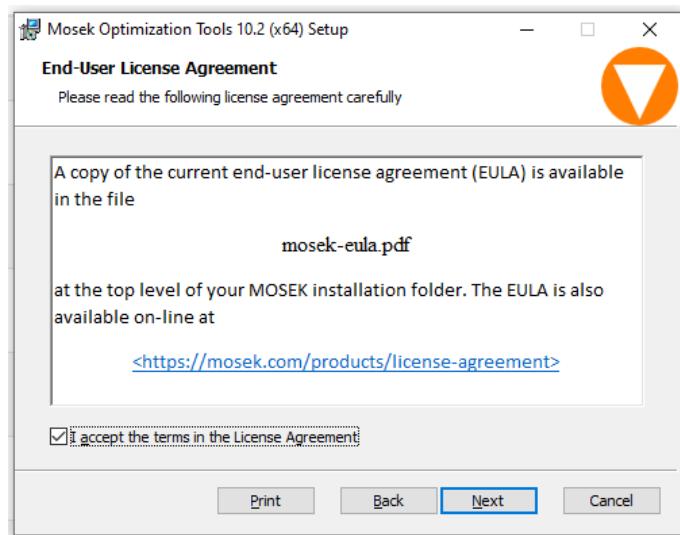
**Important:** The Default Installer for Windows requires administrator rights. If you do not have it, use the Manual Installer below. Consult the installation section in the documentation for detailed install instructions.

**Figure A.65:** Default installers (preferred) section of the Mosek downloads webpage.

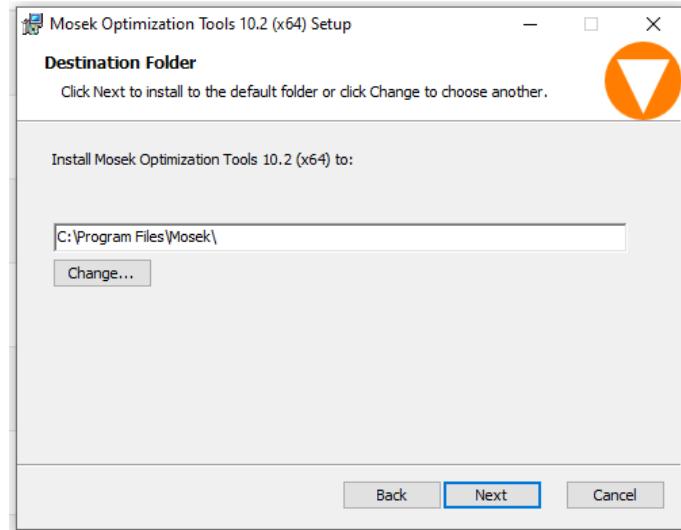
4. Step through the setup wizard as shown in the following figures.



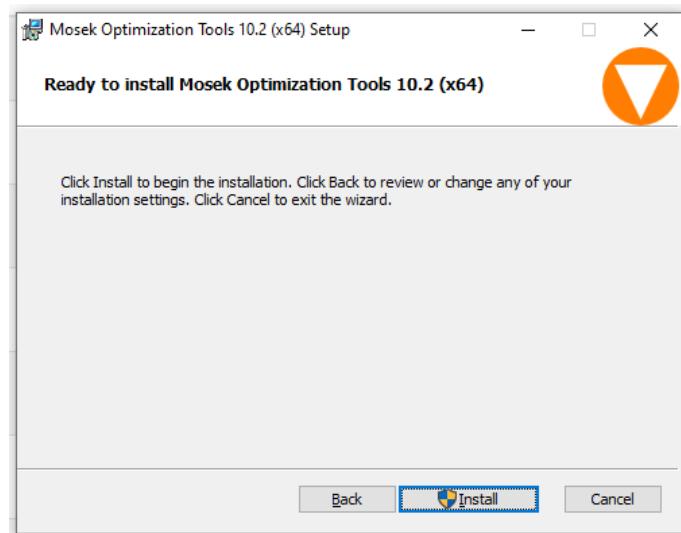
**Figure A.66:** Page 1 of the Mosek setup wizard.



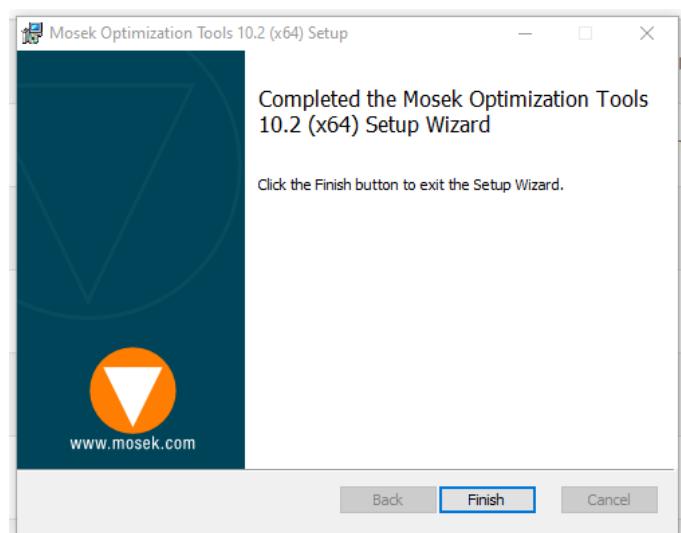
**Figure A.67:** Page 2 of the Mosek setup wizard.



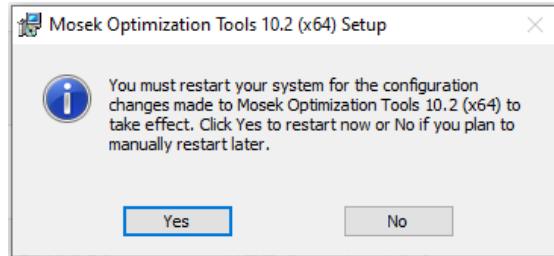
**Figure A.68:** Page 3 of the Mosek setup wizard.



**Figure A.69:** Page 4 of the Mosek setup wizard.



**Figure A.70:** Page 5 of the Mosek setup wizard.



**Figure A.71:** Page 6 of the Mosek setup wizard.

5. Head to the following webpage <https://www.mosek.com/products/academic-licenses/> once your computer has restarted. This is shown in Figure A.72.
6. Click on request personal academic license to launch the page shown in Figure A.73.

Academic Licenses

Personal Academic License

Just like we offer commercial users a chance to try MOSEK with our Trial License, we also provide academic faculty, students or staff a free license. This license can only be used for research or educational purposes at degree-granting academic institutions. In order to receive this license file, the request must be made using your academic email address.

- Available only for academic users
- Includes all features except the AMPL shell
- Not size restricted
- Valid for 365 days, but can be renewed

NOTE: To ensure positive response, use an academic email address in the application form.

[Request Personal Academic License](#)

Institutional Academic License

**Figure A.72:** Mosek webpage for requesting an academic license.

License Request

Mosek License

Request type\*

Personal Academic License

[Proceed](#) [Back to Home](#)

+45 71 74 93 73 (Office)  
+45 71 74 57 00 (Sales)

Fruebjergvej 3, Symbion Science Park, 2100 Copenhagen,  
Denmark

[sales@mosek.com](mailto:sales@mosek.com)

© 2024 Mosek. All rights reserved. [Privacy Policy](#).

**Figure A.73:** Mosek license request type.

7. Fill out the details in the subsequent pages shown in Figure A.74 and Figure A.75.

The screenshot shows the 'License Request' page for a 'Personal Academic License'. The page includes fields for Name (placeholder: 'Your First and Last Name'), E-mail Address\*, Organization (placeholder: 'Company or Educational Institution Name'), and a checkbox for 'Subscribe to MOSEK Newsletter' (checked). Below the organization field is a note: 'Expect 1-4 emails a year.' At the bottom are two buttons: 'Request License' (orange) and 'Back to License Request'.

**Figure A.74:** Further details required for the Mosek license request.

The screenshot shows the 'License Request' page with the title 'License Agreement'. It contains a message: 'We sent an e-mail containing the link to accept MOSEK's License Agreement to [redacted]. After accepting it, we will send the license file to your e-mail.' Below this is a note: 'If you **do not** receive the e-mail:' followed by a numbered list: 1. Click here to resend the License Agreement; 2. Check if your e-mail address is correct, eventually, submit a new license request; 3. Check your spam folder; 4. If the tips above do not help, contact us ([support@mosek.com](mailto:support@mosek.com)). At the bottom are two buttons: 'Back to License Request' and 'Back to Home'.

**Figure A.75:** Final page for the Mosek license request.

8. Click on the link sent to your inbox which will take you to the page shown in Figure A.76.
9. Accept the license as shown in Figure A.77.

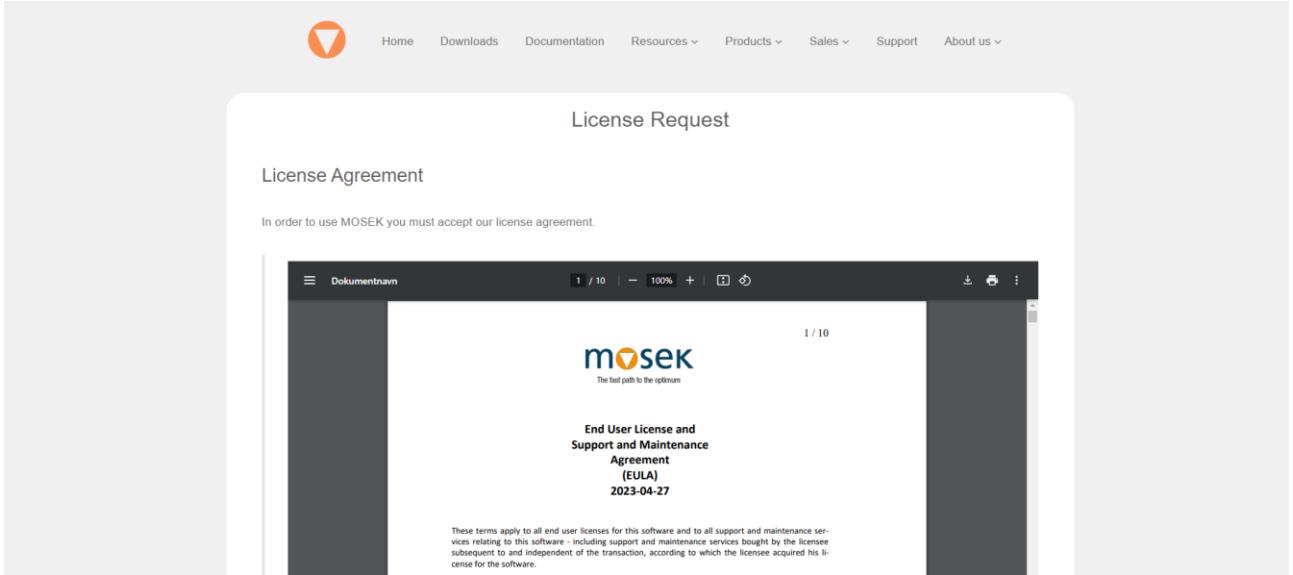


Figure A.76: Mosek license agreement webpage sent via email.

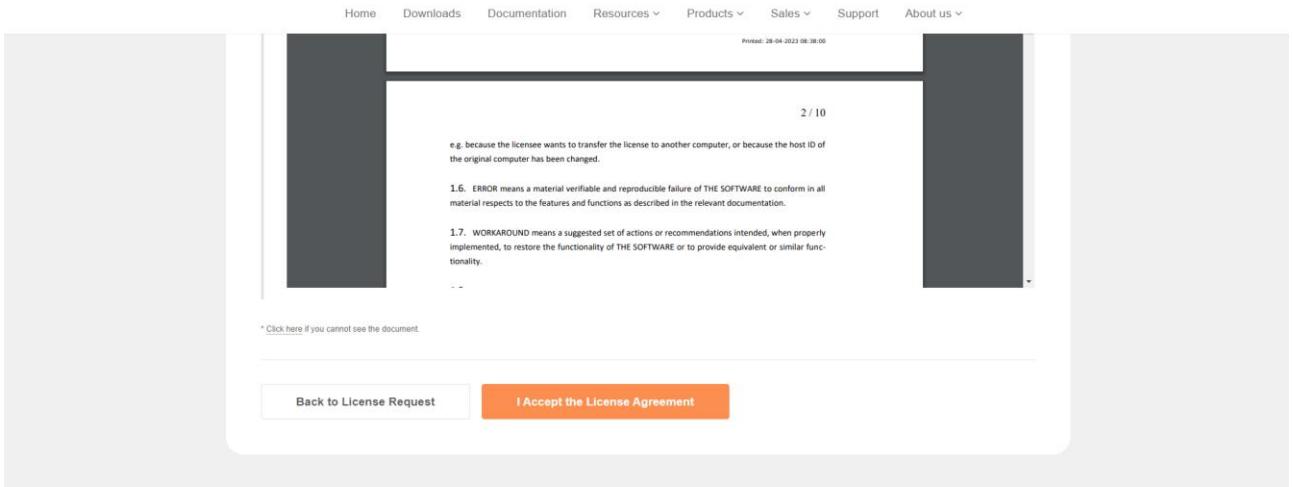


Figure A.77: Mosek license agreement acceptance section.

10. Follow the final installation instructions shown in the Mosek email as in Figure A.78 which involves placing the attached license file in your file directory as shown in Figure A.79.

This email contains a Personal Academic License file valid until **2025-oct-01** for the MOSEK Optimization Tools version 10. This license is backward compatible, meaning it supports both current and earlier versions of MOSEK.

Although your license expires on the date above, Mosek allows you to submit a request for a new license up to 30 days before this date.

The license file should be placed inside a folder called "mosek" under the user's home directory (\$HOME/mosek/mosek.lic or %USERPROFILE%\mosek\mosek.lic). In most typical cases that will be:

/home/YOUR\_USER\_NAME/mosek/mosek.lic (Linux)  
/Users/YOUR\_USER\_NAME/mosek/mosek.lic (OSX)  
C:\Users\YOUR\_USER\_NAME\mosek\mosek.lic (Windows)

Where *YOUR\_USER\_NAME* is your user ID on the computer.

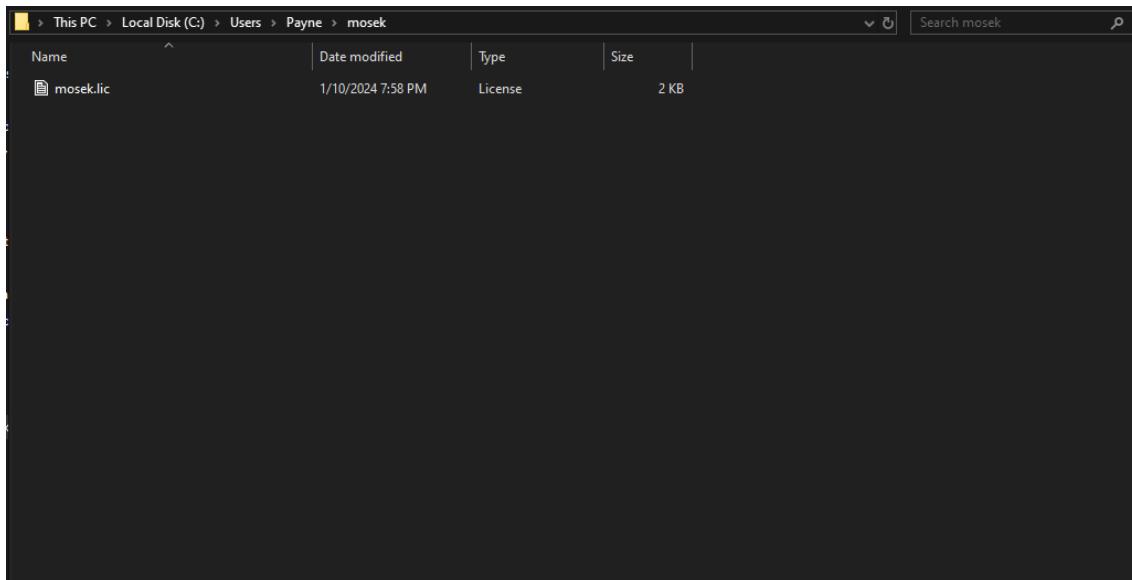
#### Troubleshooting

In [this section](#) of our documentation you will find more advanced options for locating the license file. Running a license debugging tool, such as "msktestlic" in the command line or "mosekdir" in MATLAB, can help you resolve issues with the license path.

These instructions assume the OS environment variable *MOSEKLM\_LICENSE\_FILE* has **not** been changed. If the variable was changed, it should point to the license file location.

If you are a **MATLAB user**, remember to restart MATLAB after updating an existing license file. If you used the manual installer on Windows, ensure the folder with MOSEK binaries (.../bin) is in the environment variable PATH.

**Figure A.78:** Mosek license agreement instructions.



**Figure A.79:** Placement of the Mosek license file in accordance with the email instructions.

After successfully installing Mosek, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: ['GLPK_CMD', 'CPLEX_CMD', 'GUROBI', 'GUROBI_CMD', 'MOSEK',  
'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY', 'HiGHS']
```

## COPT

The final solver tested in this project is COPT. Presented in the following is the COPT installation guide.

1. Head to <https://www.copt.de/> as depicted in Figure A.80.

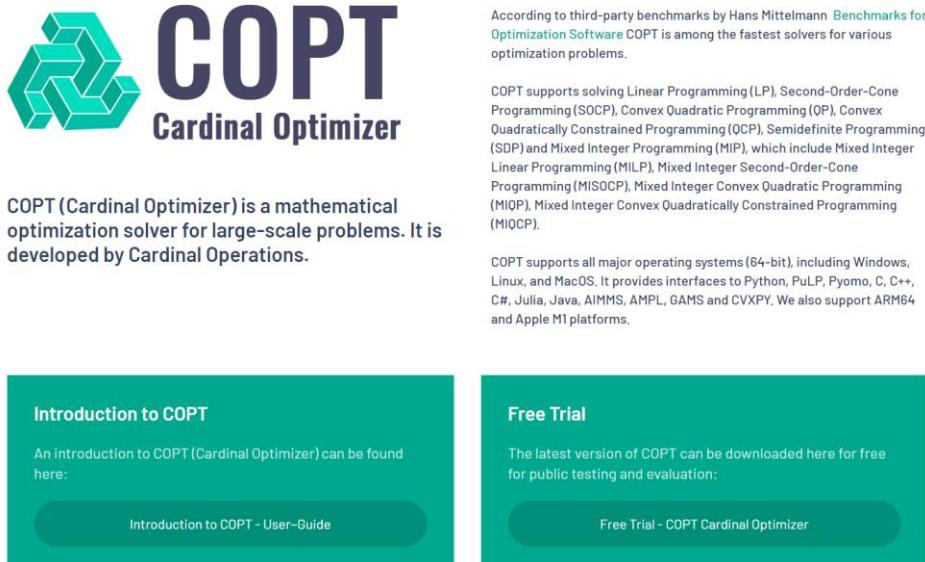


Figure A.80: COPT solver homepage.

2. Click free trial which redirects you to the page shown in Figure A.81.

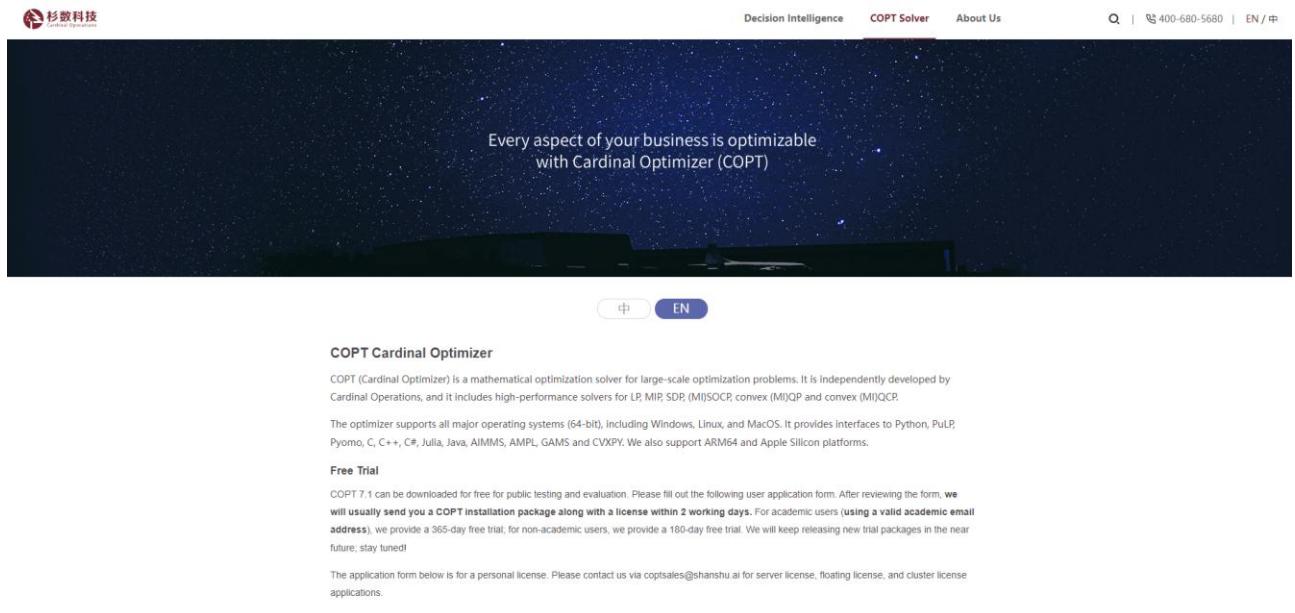


Figure A.81: COPT free trial webpage.

3. Scroll down to the section shown in Figure A.82 and fill out the required details.

**Basic information**

\* Trial Type:  
 Business user, maximum 180-day free trial  
 Academic user, 365-day free trial (renewable), please use a valid academic email address

\* Name: \_\_\_\_\_ \* Email Address: Please be sure to enter a valid address  
academic or work email is preferred

Phone: \_\_\_\_\_ \* University/ Research Institution: \_\_\_\_\_

\* Major/ Field of Research: select \* Academic Role: select

\* Country/ Region: \_\_\_\_\_ \* City: \_\_\_\_\_

\* Channels to know COPT: select

\* Reasons for application & the scenarios that you need COPT:  
 \_\_\_\_\_

TOP  
REFRESH  
PRINT  
HOME

**Figure A.82:** Basic information section of the COPT trial webpage.

4. Complete system details section shown in Figure A.83.

**System information**

Please Select Your Operating System

\* 64bit OS   \* Windows    MacOS (Universal)    Linux    Linux ARM

Please provide us with your computer username, which can be obtained by the commands listed below.

\* UserName:  required

Subscribe to COPT Email Notifications ?

I have read and accept to the [End User License Agreement \(EULA\)](#) and [Privacy Policy](#).

**Submit**

**How to obtain username**

Windows  
 command:  
echo %USERNAME%

or

whoami

Regarding the output of whoami in the form of, for example, desktop-abc123\Yonghu, please ignore desktop-abc123 and input Yonghu only.

TOP  
REFRESH  
PRINT  
HOME

**Figure A.83:** System information section of the COPT trial webpage.

5. Open the confirmation email shown in Figure A.84 and Figure A.85.
6. Click the download link shown by the green box in Figure A.84.

感谢您申请杉数求解器Cardinal Optimizer (COPT)。我们很高兴为您提供 365 天的免费试用权限。

Thanks for your application for Cardinal Optimizer (COPT). We are pleased to offer you a 365-day free trial.

邮件中发送给您的是COPT 7.1.7 的安装包和许可文件。相较于7.0版本，COPT 7.1进一步提升了混合整数规划和凸二次（约束）规划求解器性能，提升了线性规划等求解模块的性能和稳定性。COPT 7.1添加了支持GPU的一阶算法线性规划求解器，新增了对指数锥的支持。COPT可用于高效、稳定地求解线性规划、混合整数规划、（混合整数）二阶锥规划、半定规划、（混合整数）凸二次规划和（混合整数）凸二次约束规划问题。

The installation package and license files for COPT 7.1.7 are included in the email. Compared to version 7.0, COPT 7.1 further improves the performance of MILP and convex Q(C)P solver, and enhances the performance and stability of LP and other solving modules. COPT 7.1 adds the first-order method LP solver with GPU support, and adds the support for exponential cone. COPT can be used to solve LP, MILP, (MI)SOCP, SDP, convex (MI)QP and convex (MI)QCP problems efficiently and reliably.

下面为安装包的下载链接以及您的 365 天免费试用的密钥，附件中为您的许可授权文件。请您阅读安装包中的用户手册，按照其中教程步骤进行安装和配置。

Here are the download links for the installation package and the key for your 365-day free trial. Attached are your license files. Please read the user guide in the installation package and follow the tutorial steps to install and configure it.

请根据您的系统进行安装包下载：

Please download the package according to your operating system:

<https://pub.shanshu.ai/download/copt/7.1.7/win64/CardinalOptimizer-7.1.7-win64-installer.zip>  
<https://pub.shanshu.ai/download/copt/7.1.7/win64/CardinalOptimizer-7.1.7-win64.zip>

请您下载附件中的软件许可文件("license.key"和"license.dat")。

Please download the attached license files ("license.key" and "license.dat").

我们推荐在用户目录（以Windows系统为例，用户目录形如“C:\Users\username”）中新建文件夹“copt”，并移动两个许可文件至“copt”文件夹中，即可完成许可安装。

We recommend you to create a new folder "copt" in the user directory (Taking Windows for example, the user directory looks like "C:\Users\username"), and move the two files to the "copt" folder to complete the license installation.

此外，我们同样提供了软件密钥key，您也可以通过key自行获取许可文件并安装，详细步骤请参考用户手册许可配置章节。

In addition, the software key is provided. You can also obtain the license files with the key below and complete the license installation yourself. (Please refer to the license configuration chapter of user guide for details).

**Figure A.84:** Part 1 of the COPT confirmation email.

您的软件密钥 (Your Key) :

注意：

1) 试用许可仅在一台机器上使用，并已绑定您在申请免费试用时填写的username。

NOTE that the license can only be used in one machine and has been bound to the username you filled in during your free-trial application.

2) 安装完毕后，电脑中会出现“copt71”文件夹，该文件夹下的“docs”中可以找到用户手册（以Windows电脑为例，用户手册的位置在：C:\Program Files\copt71\docs）。

After installation, a "copt71" folder will appear in the computer, and the user guide can be found in the "docs" under this folder (Taking Windows for example, the user guide is located in: C:\Program Files\copt71\docs).

3) 在联网条件下，我们推荐安装COPT Python接口的方式为：

If Internet connection is available, we recommend to install and upgrade the COPT Python interface via:

```
pip install copty  
pip install --upgrade copty
```

Welcome to contact us

Email (Technical Support): [coptsupport@shanshu.ai](mailto:coptsupport@shanshu.ai)

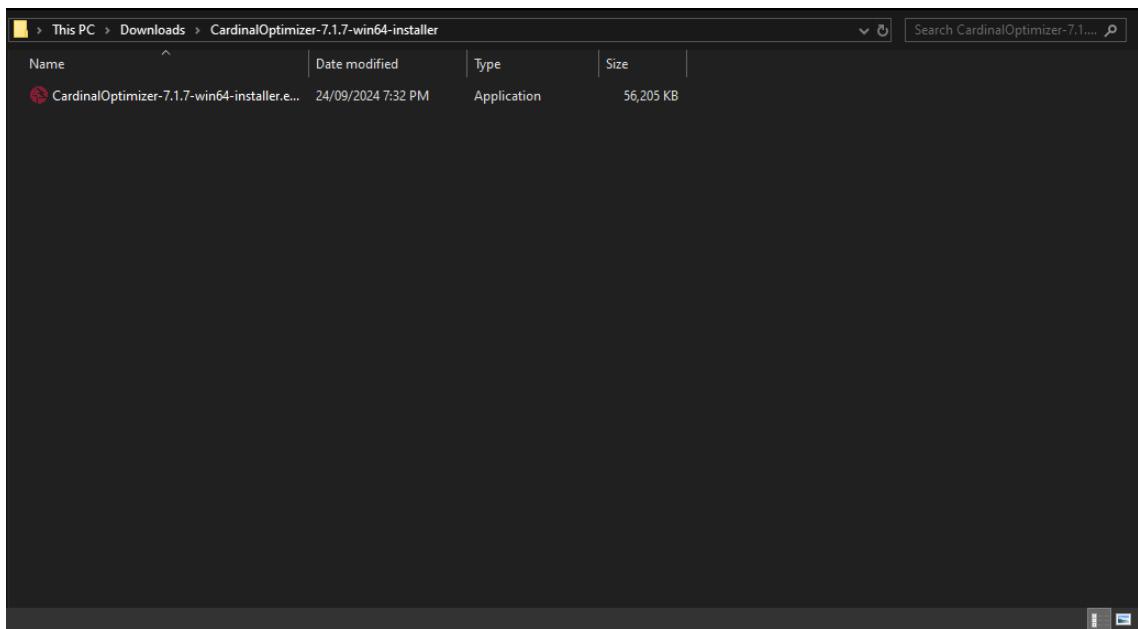
Email (Business Contact): [coptsales@shanshu.ai](mailto:coptsales@shanshu.ai)

QQ Group: 142636109

Website: <https://www.shanshu.ai>

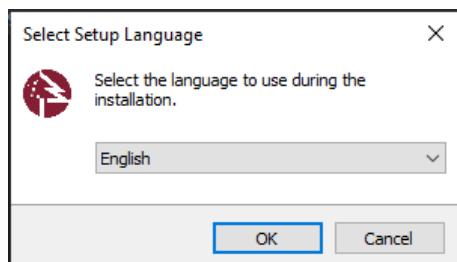
**Figure A.85:** Part 2 of the COPT confirmation email.

7. Extract the downloaded file and execute the application shown in Figure A.86.

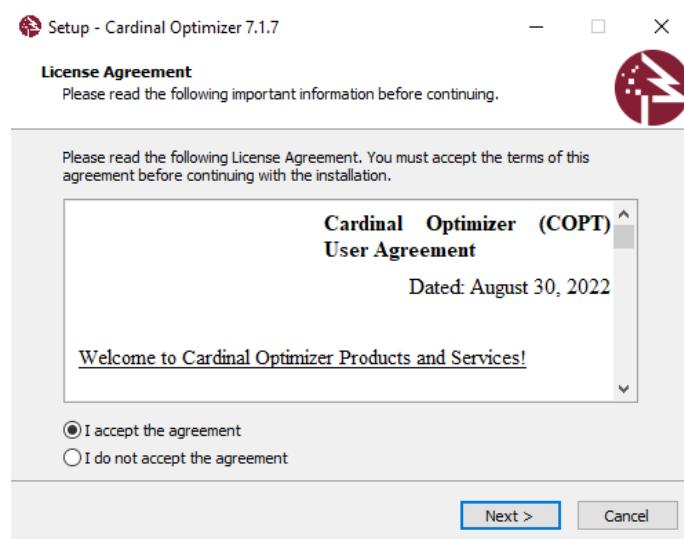


**Figure A.86:** Extracted executable file contained in the COPT email link.

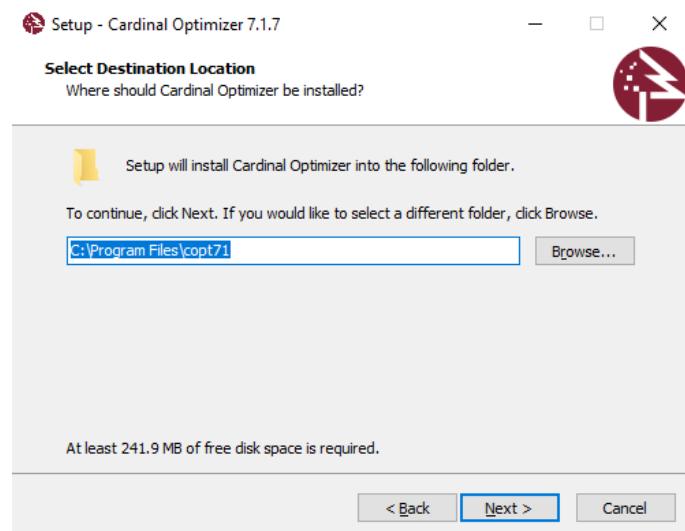
8. Complete the setup wizard outlined in the following figures.



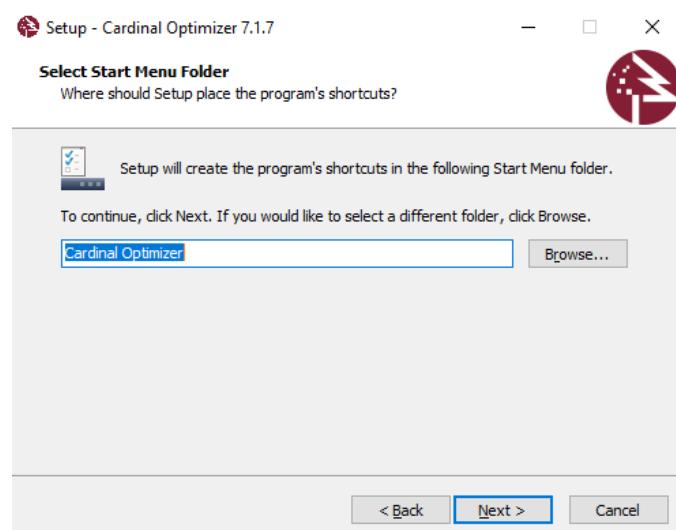
**Figure A.87:** Page 1 of the COPT setup wizard.



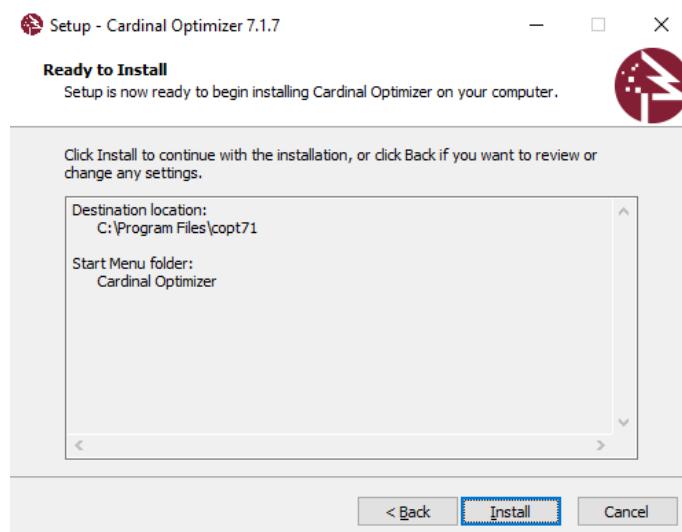
**Figure A.88:** Page 2 of the COPT setup wizard.



**Figure A.89:** Page 3 of the COPT setup wizard.



**Figure A.90:** Page 4 of the COPT setup wizard.

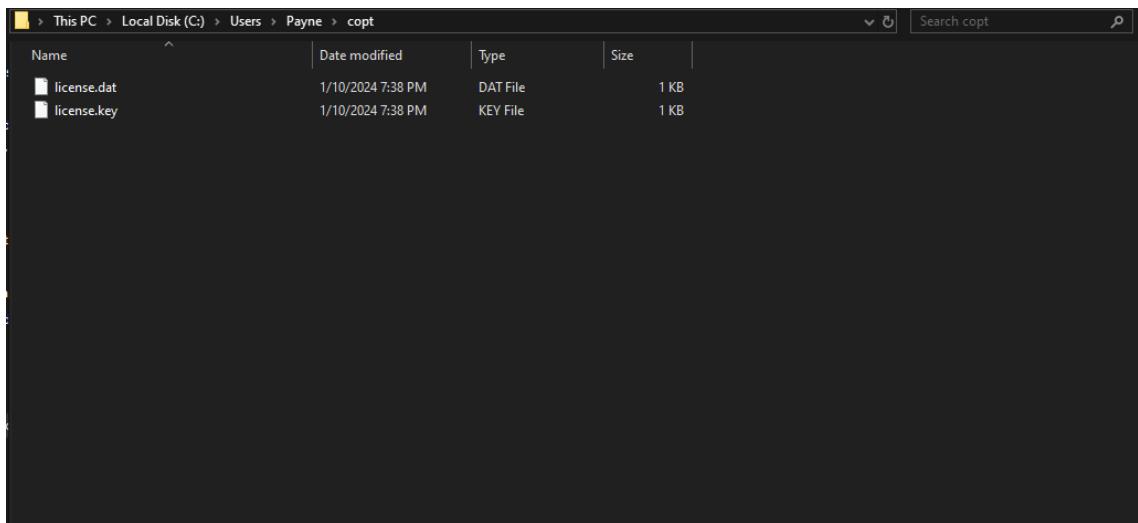


**Figure A.91:** Page 5 of the COPT setup wizard.



**Figure A.92:** Page 6 of the COPT setup wizard.

9. Ensure that the license files attached in the email are placed in a file location. As specified by the email from COPT, the recommended location is C:/Users/<Username>/copt as shown in Figure A.93.



**Figure A.93:** Recommended location of the COPT licence files.

After successfully installing COPT, relaunch your code editor/environment and the available solver list should be updated as shown below.

```
Available Solvers: ['GLPK_CMD', 'CPLEX_CMD', 'GUROBI', 'GUROBI_CMD', 'MOSEK',  
'PULP_CBC_CMD', 'COIN_CMD', 'SCIP_PY', 'HiGHS', 'COPT_CMD']
```