Installation guide for k_aug - prepared by Michael Short

k_aug is a package for calculating Karush-Kuhn-Tucker matrix sensitivity and reduced hessian computation. It was developed by David M. Thierry at Carnegie Mellon University in collaboration with Prof Lorenz T. Biegler at the Center for Advanced Process Decision-making (CAPD). k_aug is compatible with Pyomo and AMPL via ASL and its main functionality can be accessed through suffixes. k_aug assumes that the user is using the Ipopt (interior point optimizer) solver (Waechter and Biegler, 2006), which is used for large-scale nonlinear programming. Ipopt is available for free from:

https://projects.coin-or.org/Ipopt

In order to use k_aug, Ipopt needs to be installed and added to the system's path. A detailed installation guide for Ipopt is available at the previous link as well.

This guide is intended to assist users installing k_aug on Linux and Windows systems. Unfortunately k_aug is not currently available for MacOS.

For Linux:

Download k_aug from https://github.com/dthierry/k_aug. In a terminal navigate to the folder where k_aug is unpacked and then enter the asl folder before running the get script:

```
cd k_aug/thirdparty/asl
./get.ASL
```

Check that script correctly terminated and that there are no errors. If an error occurred then it is important to check that all of the dependencies have been installed. A full list of dependencies is found under the Windows install instructions.

After the ASL script is successfully compiled it is then necessary to install the other packages in the following order using these commands:

```
cd ../openblas
./get.openblas
```

Check that the script was successfully run as above then:

```
cd ../metis
./help.metis
```

Check and move onto the next script:

```
cd ../scotch
./help.scotch
```

Check install and then:

```
cd ../mumps
./help.mumps
```

Following the correct installation of all of these packages, the HSL solver mc19 needs to be obtained from the following website:

http://www.hsl.rl.ac.uk/download/MC19/1.0.0/a/

Once you provide an email address, you will be sent a download link. To use the script in k_aug, make sure that the tar.gz is downloaded and placed in k_aug\thirdparty\hsl\mc19.

```
cd hsl/mc19
./help.mc19
```

Finally, return to the root and then finish compiling k_aug:

```
cd ../../..
cmake CMakeLists.txt
make
```

Once this is successfully compiled it is just necessary to check that the k_aug.exe is now in the k_aug/bin folder and that this folder is added to the Linux Path. This can be done using:

```
export PATH=$PATH:/usr/home/k_aug/bin
```

Or wherever you have placed the k_aug folder on your computer.

For Windows:

1. Install Cygwin

First, download Cygwin from https://www.cygwin.com/. Cygwin is a environment that mimics a UNIX-like system and allows the user to recompile and run programs on Windows without having to modify the source code. When installing Cygwin, during the package download section, ensure that the following list of requirements are included:

- cmake
- gcc-core
- gfortran
- g++
- git
- make
- wget
- zlib-devel

This can be done by searching for them in the package search bar. If a package is forgotten or not found then one can use wget to install apt-cyg, which can be used similarly to pip or apt-get in Linux to install packages. Install apt-cyg using wget in the Cygwin command line:

```
lynx -source rawgit.com/transcode-open/apt-cyg/master/apt-cyg > apt-cyg
```

```
install apt-cyg /bin
```

To install a package using apt-cyg:

```
apt-cyg install git
```

After installing Cygwin with the relevant packages we can begin installing k_aug.

2. Install k_aug

First, download the .zip from https://github.com/dthierry/k_aug under “Clone or download”. Place this folder into the Cygwin home folder, C:\cygwin64\home\YOURUSERNAME\ and unzip.

Next, launch the Cygwin command line and navigate to the appropriate folder using:

```
cd k_aug-master
```

Then enter the thirdparty folder and in order install:

```
cd thirdparty/asl
```

```
./get.ASL
```

Make sure that the script ran successfully. You should have some message that confirms successful installation. If there is an error, make sure that Cygwin has all the necessary packages mentioned above. If something was missing either re-install Cygwin including all of the packages and sub-packages mentioned in the list above, or try using apt-cyg to get the relevant packages.

Next:

```
cd ../openblas
```

```
./get.openblas
```

Check that the script was successfully run as above then:

```
cd ../metis
```

```
./help.metis
```

Check and move onto the next script:

```
cd ../scotch
```

```
./help.scotch
```

Check install and then:

```
cd ../mumps
```

```
./help.mumps
```

The MUMPS linear solver package can potentially take a while to install. Once this has been successfully installed it is then necessary to install the mc19 linear solvers. These solvers are not redistributable, but are freely available from the HSL software library:

http://www.hsl.rl.ac.uk/download/MC19/1.0.0/a/

You will just need to provide an email and then will be sent a download link. To use the script in k_aug, make sure that the tar.gz is downloaded and placed in k_aug\thirdparty\hsl\mc19.

Use Cygwin to enter this folder and then run the script:

```
cd hsl/mc19
./help.mc19
```

Finally, return to the root and then finish compiling k_aug:

```
cd ../../..
cmake CMakeLists.txt
make
```

Check that the bin directory contains k_aug.exe. This confirms that the installation was successful. The last steps are to add the following to the path. This is done by right-clicking on “This PC”, selecting “Properties”, then under “Advanced system settings” go to the “Environment Variables…” button at the bottom. Under “User variables” or “System variables” select Path and click “Edit…”. Now select New and add the following two folders:

C:\cygwin64\home\YOURUSERNAME\k_aug\bin

And

C:\cygwin64\home\YOURUSERNAME\k_aug\thirdparty\openblas\OpenBLAS

And now we are ready to use k_aug!