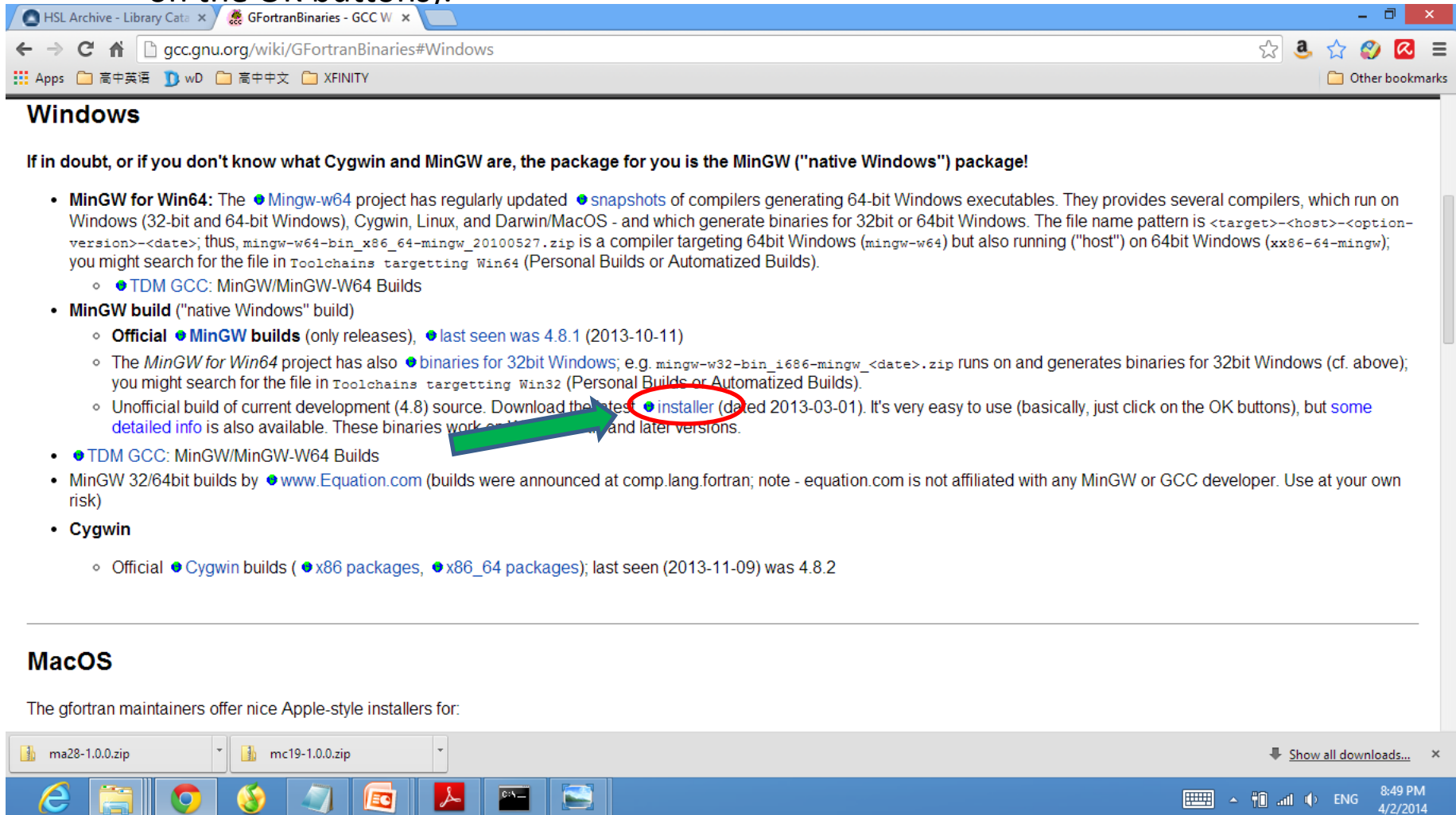


A Step-by-Step Tutorial for making MA28.dll and running GEBT

- Step 1: Download and install gfortran compiler.
 - 1.1 Go to <http://gcc.gnu.org/wiki/GFortranBinaries#Windows> .
 - 1.2 Click on the “installer” (shown below) for Windows OS. Run the downloaded exe file, follow the instructions to install the gfortran compiler (basically just click on the OK buttons).



The screenshot shows a web browser window with the address bar displaying gcc.gnu.org/wiki/GFortranBinaries#Windows. The page title is "Windows". The main content area contains the following text:

If in doubt, or if you don't know what Cygwin and MinGW are, the package for you is the MinGW ("native Windows") package!

- **MinGW for Win64:** The [Mingw-w64](#) project has regularly updated [snapshots](#) of compilers generating 64-bit Windows executables. They provides several compilers, which run on Windows (32-bit and 64-bit Windows), Cygwin, Linux, and Darwin/MacOS - and which generate binaries for 32bit or 64bit Windows. The file name pattern is <target>-<host>-<option-version>-<date>; thus, mingw-w64-bin_x86_64-mingw_20100527.zip is a compiler targeting 64bit Windows (mingw-w64) but also running ("host") on 64bit Windows (x86_64-mingw); you might search for the file in Toolchains targetting Win64 (Personal Builds or Automatized Builds).
 - [TDM GCC: MinGW/MinGW-W64 Builds](#)
- **MinGW build ("native Windows" build)**
 - **Official [MinGW builds](#)** (only releases), [last seen was 4.8.1](#) (2013-10-11)
 - The *MinGW for Win64* project has also [binaries for 32bit Windows](#); e.g. mingw-w32-bin_i686-mingw_<date>.zip runs on and generates binaries for 32bit Windows (cf. above); you might search for the file in Toolchains targetting Win32 (Personal Builds or Automatized Builds).
 - Unofficial build of current development (4.8) source. Download the latest [installer](#) (dated 2013-03-01). It's very easy to use (basically, just click on the OK buttons), but [some detailed info](#) is also available. These binaries work on Windows XP and later versions.
- [TDM GCC: MinGW/MinGW-W64 Builds](#)
- MinGW 32/64bit builds by [www.Equation.com](#) (builds were announced at comp.lang.fortran; note - equation.com is not affiliated with any MinGW or GCC developer. Use at your own risk)
- **Cygwin**
 - Official [Cygwin builds](#) ([x86 packages](#), [x86_64 packages](#)); last seen (2013-11-09) was 4.8.2

The word "installer" in the third bullet point is circled in red, and a green arrow points to it from the left.

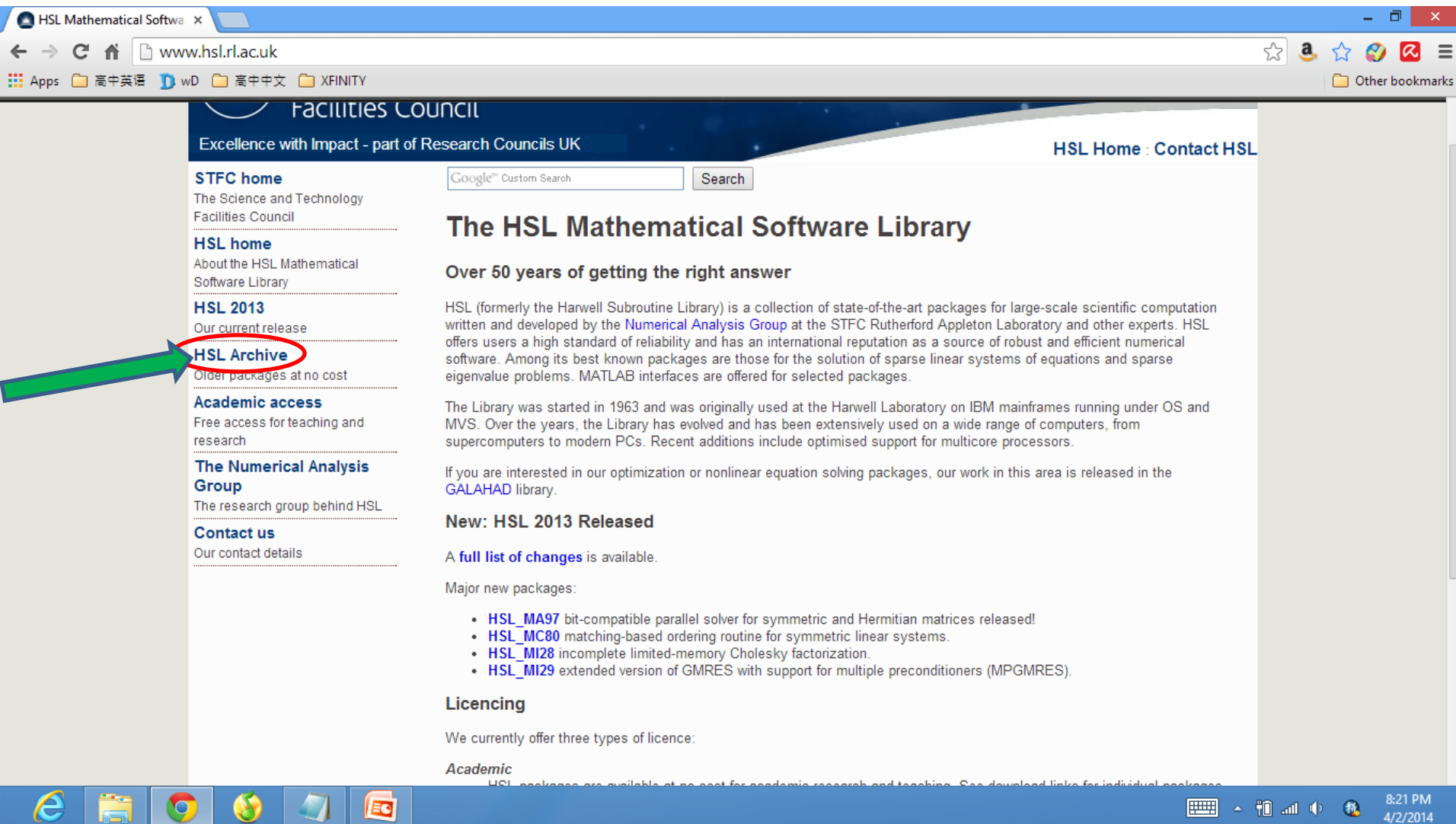
Below the text, there is a section titled "MacOS".

The MacOS section contains the text: "The gfortran maintainers offer nice Apple-style installers for:"

At the bottom of the screenshot, there is a taskbar showing several application icons, including Internet Explorer, File Explorer, Google Chrome, and a terminal window. The system clock in the bottom right corner shows 8:49 PM on 4/2/2014.

Step 2: Download MA28 and MC19

- 2.1 Create a new folder “MA28” as working directory.
- 2.2 Go to: <http://www.hsl.rl.ac.uk/> .
 - 2.2.1 Click “HSL Archive” on the left column, see figure below.



The screenshot shows the HSL Mathematical Software Library website. The browser address bar displays www.hsl.rl.ac.uk. The page header includes the Facilities Council logo and the text "Excellence with Impact - part of Research Councils UK". The main content area is titled "The HSL Mathematical Software Library" and features a search bar, a description of the library, and a list of recent releases. The left sidebar contains navigation links, with "HSL Archive" highlighted by a green arrow and a red circle.

Facilities Council
Excellence with Impact - part of Research Councils UK

HSL Home : [Contact HSL](#)

STFC home
The Science and Technology
Facilities Council

HSL home
About the HSL Mathematical
Software Library

HSL 2013
Our current release

HSL Archive
Older packages at no cost

Academic access
Free access for teaching and
research

**The Numerical Analysis
Group**
The research group behind HSL

Contact us
Our contact details

The HSL Mathematical Software Library

Over 50 years of getting the right answer

HSL (formerly the Harwell Subroutine Library) is a collection of state-of-the-art packages for large-scale scientific computation written and developed by the [Numerical Analysis Group](#) at the STFC Rutherford Appleton Laboratory and other experts. HSL offers users a high standard of reliability and has an international reputation as a source of robust and efficient numerical software. Among its best known packages are those for the solution of sparse linear systems of equations and sparse eigenvalue problems. MATLAB interfaces are offered for selected packages.

The Library was started in 1963 and was originally used at the Harwell Laboratory on IBM mainframes running under OS and MVS. Over the years, the Library has evolved and has been extensively used on a wide range of computers, from supercomputers to modern PCs. Recent additions include optimised support for multicore processors.

If you are interested in our optimization or nonlinear equation solving packages, our work in this area is released in the [GALAHAD](#) library.

New: HSL 2013 Released

A [full list of changes](#) is available.

Major new packages:

- [HSL_MA97](#) bit-compatible parallel solver for symmetric and Hermitian matrices released!
- [HSL_MC80](#) matching-based ordering routine for symmetric linear systems.
- [HSL_MI28](#) incomplete limited-memory Cholesky factorization.
- [HSL_MI29](#) extended version of GMRES with support for multiple preconditioners (MPGMRES).

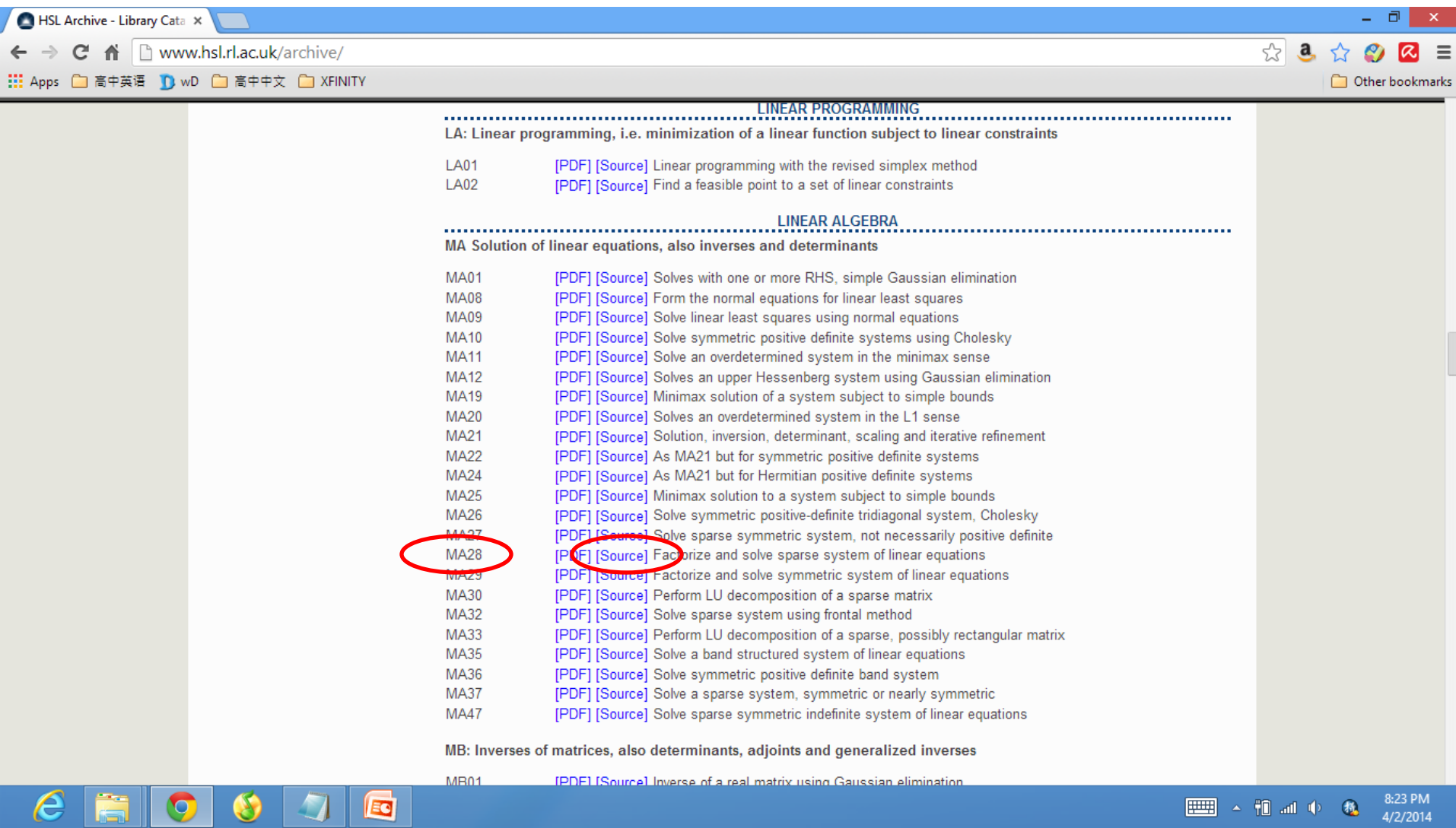
Licensing

We currently offer three types of licence:

Academic
HSL packages are available at no cost for academic research and teaching. See download links for individual packages.

Step 2: Download MA28 and MC19 (continued)

- 2.2.2 Scroll down on the Archive page to “LINEAR ALGEBRA”.
- 2.2.3 Click on “Source” of MA28 and MC19, respectively.



The screenshot shows a web browser window with the URL www.hsl.rl.ac.uk/archive/. The page is titled "HSL Archive - Library Catalogue". It lists various mathematical software routines under the heading "LINEAR ALGEBRA". The entry MA28 is circled in red, and its "Source" link is also circled in red. The entry MA28 is described as "Factorize and solve sparse system of linear equations".

LINEAR PROGRAMMING

LA: Linear programming, i.e. minimization of a linear function subject to linear constraints

LA01 [PDF] [Source] Linear programming with the revised simplex method

LA02 [PDF] [Source] Find a feasible point to a set of linear constraints

LINEAR ALGEBRA

MA: Solution of linear equations, also inverses and determinants

MA01 [PDF] [Source] Solves with one or more RHS, simple Gaussian elimination

MA08 [PDF] [Source] Form the normal equations for linear least squares

MA09 [PDF] [Source] Solve linear least squares using normal equations

MA10 [PDF] [Source] Solve symmetric positive definite systems using Cholesky

MA11 [PDF] [Source] Solve an overdetermined system in the minimax sense

MA12 [PDF] [Source] Solves an upper Hessenberg system using Gaussian elimination

MA19 [PDF] [Source] Minimax solution of a system subject to simple bounds

MA20 [PDF] [Source] Solves an overdetermined system in the L1 sense

MA21 [PDF] [Source] Solution, inversion, determinant, scaling and iterative refinement

MA22 [PDF] [Source] As MA21 but for symmetric positive definite systems

MA24 [PDF] [Source] As MA21 but for Hermitian positive definite systems

MA25 [PDF] [Source] Minimax solution to a system subject to simple bounds

MA26 [PDF] [Source] Solve symmetric positive-definite tridiagonal system, Cholesky

MA27 [PDF] [Source] Solve sparse symmetric system, not necessarily positive definite

MA28 [PDF] [Source] Factorize and solve sparse system of linear equations

MA29 [PDF] [Source] Factorize and solve symmetric system of linear equations

MA30 [PDF] [Source] Perform LU decomposition of a sparse matrix

MA32 [PDF] [Source] Solve sparse system using frontal method

MA33 [PDF] [Source] Perform LU decomposition of a sparse, possibly rectangular matrix

MA35 [PDF] [Source] Solve a band structured system of linear equations

MA36 [PDF] [Source] Solve symmetric positive definite band system

MA37 [PDF] [Source] Solve a sparse system, symmetric or nearly symmetric

MA47 [PDF] [Source] Solve sparse symmetric indefinite system of linear equations

MB: Inverses of matrices, also determinants, adjoints and generalized inverses

MB01 [PDF] [Source] Inverse of a real matrix using Gaussian elimination

Step 2: Download MA28 and MC19 (continued)

– 2.2.4 Check “Personal License” .

The screenshot shows a web browser window with the URL www.hsl.rl.ac.uk/download/MA28/1.0.0/a/. The page header features the Science & Technology Facilities Council logo and the text "Excellence with Impact - part of Research Councils UK". The main heading is "HSL package download request". Under the heading, there are two radio button options: "Personal Licence (allows use without redistribution)" and "Incorporation Licence (allows redistribution as part of your software)". The "Personal Licence" option is selected and circled in red. Below the options, it states: "This method of obtaining HSL software is **strictly** intended for:" followed by a bulleted list: "Personal use." and "Without redistribution in source or binary form." A note follows: "If you do not meet these criteria and wish to discuss alternative licencing arrangements, or have any other questions, please contact hsl@stfc.ac.uk." The page is divided into sections: "The Software" and "The Agreement". "The Software" section states: "You are requesting to download the **all available precisions** variant of **MA28 v1.0.0**. This package includes all HSL dependencies required to compile the software. However, for some packages you may additionally require your own BLAS and LAPACK libraries and/or the MeTiS graph partitioning package." "The Agreement" section states: "Please read the licence below, complete the registration information at the bottom, and accept the terms of the licence in order to download the software. IN THE FOLLOWING TERMS AND CONDITIONS YOU ARE REFERRED TO AS THE 'LICENSEE'." Below this, it says "HSL ARCHIVE LICENCE VERSION 1.0 MAY 2011" and "printer friendly version". The left sidebar contains links to "STFC home", "HSL home", "HSL 2013", "HSL Archive", "Academic access", "The Numerical Analysis Group", and "Contact us". The Windows taskbar at the bottom shows the time as 8:24 PM on 4/2/2014.

HSL Mathematical Software

www.hsl.rl.ac.uk/download/MA28/1.0.0/a/

Science & Technology Facilities Council

Excellence with Impact - part of Research Councils UK

HSL Home : Contact HSL

HSL package download request

I want a:

- ☒ Personal Licence (allows use without redistribution)
- ☐ Incorporation Licence (allows redistribution as part of your software)

This method of obtaining HSL software is **strictly** intended for:

- Personal use.
- Without redistribution in source or binary form.

If you do not meet these criteria and wish to discuss alternative licencing arrangements, or have any other questions, please contact hsl@stfc.ac.uk.

The Software

You are requesting to download the **all available precisions** variant of **MA28 v1.0.0**.

This package includes all HSL dependencies required to compile the software. However, for some packages you may additionally require your own BLAS and LAPACK libraries and/or the MeTiS graph partitioning package.

The Agreement

Please read the licence below, complete the registration information at the bottom, and accept the terms of the licence in order to download the software. IN THE FOLLOWING TERMS AND CONDITIONS YOU ARE REFERRED TO AS THE "LICENSEE".

HSL ARCHIVE LICENCE VERSION 1.0 MAY 2011

[printer friendly version](#)

STFC home
The Science and Technology Facilities Council

HSL home
About the HSL Mathematical Software Library

HSL 2013
Our current release

HSL Archive
Older packages at no cost

Academic access
Free access for teaching and research

The Numerical Analysis Group
The research group behind HSL

Contact us
Our contact details

8:24 PM 4/2/2014

Step 2: Download MA28 and MC19 (continued)

- 2.2.5 Fill in the information at the bottom of the webpage, click “Accept”.

HSL Mathematical Software x

www.hsl.rl.ac.uk/download/MA28/1.0.0/a/

Apps 高中英语 wD 高中中文 XFINITY Other bookmarks

accordingly the Contracts (Rights of Third parties) Act 1999 shall not apply to this Agreement.
7.9 This agreement shall be interpreted and construed in accordance with the laws of England and Wales. The English Courts will have exclusive jurisdiction to deal with any dispute which has arisen or may arise out of or in connection with this Agreement, however STFC may enforce the Licensee's obligation of confidence in the courts of any jurisdiction having competence to issue an injunction directly enforceable against the Licensee.

Please fill in the following information completely. Your application may be rejected if you do not.

About you

Name

Email

Company

Domain

City

Country

About your application

Please give a short description of your intended application

☐ Please tick this box if you are able to supply us with data for testing and improving HSL. We are particularly interested in large scale or numerically challenging problems.

By clicking "Accept" and downloading the software you are offering to enter into a legally binding agreement governed by the terms and conditions set out above. Your request will be automatically approved, and you will be sent a personalised download link to your given email address. It will be valid for 7 days. The sending of such a download link constitutes STFC's acceptance of your offer and creates a contract between you and STFC.

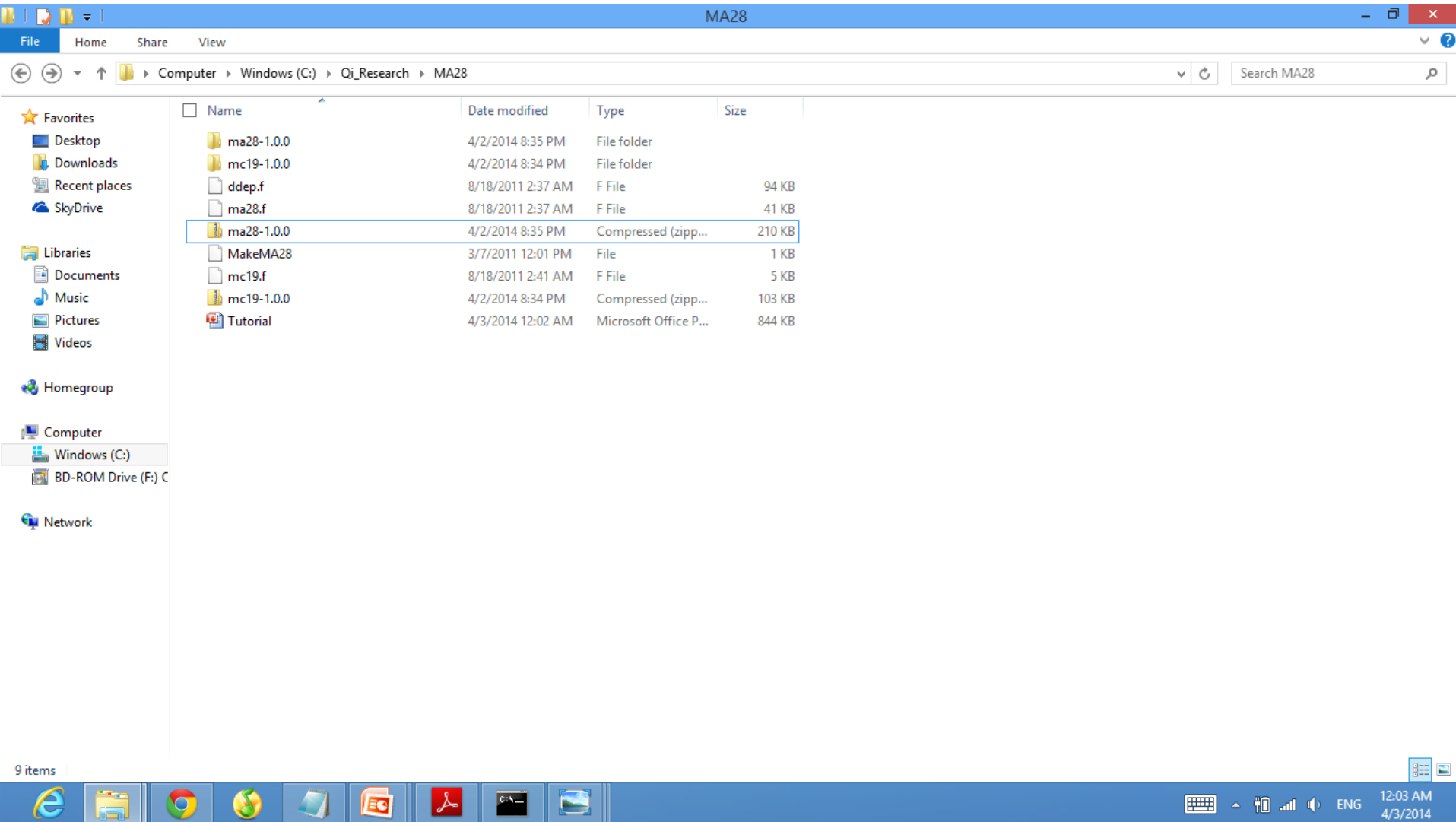
8:24 PM 4/2/2014

Step 2: Download MA28 and MC19 (continued)

- 2.2.7 You will receive a personalised download link in the email you provided in the previous step in few minutes. Click the link to download the zip file to the working folder “..\MA28” created in the Step 2.1.
- 2.2.8 Unzip these two files, you will have two folders, “mc19-1.0.0” and “ma28-1.0.0”.
- 2.2.9 Copy “mc19d.f” from ..\MA28\mc19-1.0.0\src to ..\MA28 (the working folder), rename it as “mc19.f”.
- 2.2.10 Copy “ma28d.f” from ..\MA28\ma28-1.0.0\src to ..\MA28 (the working folder), rename it as “ma28.f”.
- 2.2.11 Copy “ddeps.f” from ..\MA28\mc19-1.0.0\src to ..\MA28 (the working folder), rename it as “ddep.f”.
- 2.2.12 Copy “MakeMA28” from ..\GEBT4 (your download package from analyswift.com) to ..\MA28 (the working folder).
- 2.3 Now you have all the files needed for compiling MA28.dll. The working folder “..\MA28” should look like this (see figure on the next slide):

Step 2: Download MA28 and MC19 (continued)

– 2.3.1 Working directory “..\MA28”.



Step 2: Download MA28 and MC19 (continued)

– 2.3.2 Change variable type in mc19.f

Before compiling MA28.dll, some variables need to be modified in “mc19.f” from “REAL” to “DOUBLE PRECISION”. There are totally **four** changes needed

- Line 8 Change from “REAL” to “DOUBLE PRECISION”
- Line 18 Change from “REAL” to “DOUBLE PRECISION”
- Line 20 Change from “ALOG” to “LOG”
- Line 44 Change from “ALOG” to “LOG”, see Figure below (Change 4, Line 44, does not shown)

The screenshot displays two side-by-side windows of the Notepad++ editor, showing the file 'mc19.f' located at 'C:\Qi_Research\MA28\mc19.f'. The left window shows the original code, and the right window shows the modified code. Four specific changes are highlighted with red circles and green arrows:

- Line 8:** The variable `R(N)` is changed from `REAL` to `DOUBLE PRECISION`.
- Line 18:** The variable `E,E1` is changed from `REAL` to `DOUBLE PRECISION`.
- Line 20:** The function `ALOG` is changed to `LOG`.
- Line 44:** The function `ALOG` is changed to `LOG` (this change is not visible in the provided image).

The code in both windows is as follows:

```
1 C COPYRIGHT (c) 1977 AEA Technology.
2 C#####DATE 09 MAR 1989
3 SUBROUTINE MC19AD(N,NA,A,IRN,ICN,R,C,W)
4 INTEGER N,NA,IRN(*),ICN(*)
5 DOUBLE PRECISION A(*)
6 C IRN(K) GIVES ROW NUMBER OF ELEMENT IN A(K).
7 C ICN(K) GIVES COL NUMBER OF ELEMENT IN A(K).
8 REAL R(N),
9 C R(I) IS USED TO RETURN LOG(SCALING FACTOR FOR ROW I).
10 C C(J) IS USED TO RETURN LOG(SCALING FACTOR FOR COL J).
11 C W(I,1), W(I,2) HOLD ROW, COL NON-ZERO COUNTS.
12 C W(J,3) HOLDS - COL J LOG DURING EXECUTION.
13 C W(J,4) HOLDS 2-ITERATION CHANGE IN W(J,3).
14 C W(I,5) IS USED TO SAVE AVERAGE ELEMENT LOG FOR ROW I.
15 INTEGER LP,IFAIL
16 COMMON/MC19BD/LP,IFAIL
17 INTEGER I,I1,I2,ITER,J,K,L,MAXIT
18 REAL E,E1,
19 EXTERNAL MC19SD
20 INTRINSIC ALOG,DAIS
21 DATA MAXIT/100/,SMIN/0.1/
22 C MAXIT IS THE MAXIMAL PERMITTED NUMBER OF ITERATIONS
23 C SMIN IS USED IN A CONVERGENCE TEST ON (RESIDUAL NORM)**2
24 C
25 C CHECK SCALAR DATA
26 IFAIL=1
27 IF(N.LT.1)GO TO 230
28 IFAIL=2
29 IFAIL=0
30 C
31 C INITIALISE FOR ACCUMULATION OF SUMS AND PRODUCTS
32 DO 5 I=1,N
33 C(I)=0.
34 D/T=0
```


Step 3: Compile “MA28.dll”

- 3.1 Launch a command window in the working directory “..\MA28”.
- 3.2 Type command “make -f MakeMA28” in the command line, click “enter”.
- 3.3 A “MA28.dll” file will be generated in your working folder. Copy this “MA28.dll” to “..\GEBT4” folder.

The screenshot shows a web browser window displaying the HSL Archive website. The browser's address bar shows the URL www.hsl.rl.ac.uk/archive/. The page content lists various linear algebra solvers, including MA32, MA33, MA35, MA36, MA37, MA47, MB, MB01, MB04, MB05, and MB10. Each entry includes a brief description and links to PDF and Source files.

Overlaid on the browser window is a Windows command prompt window titled "C:\Windows\System32\cmd.exe". The command prompt shows the following text:

```
Microsoft Windows [Version 6.2.9200]
(c) 2012 Microsoft Corporation. All rights reserved.

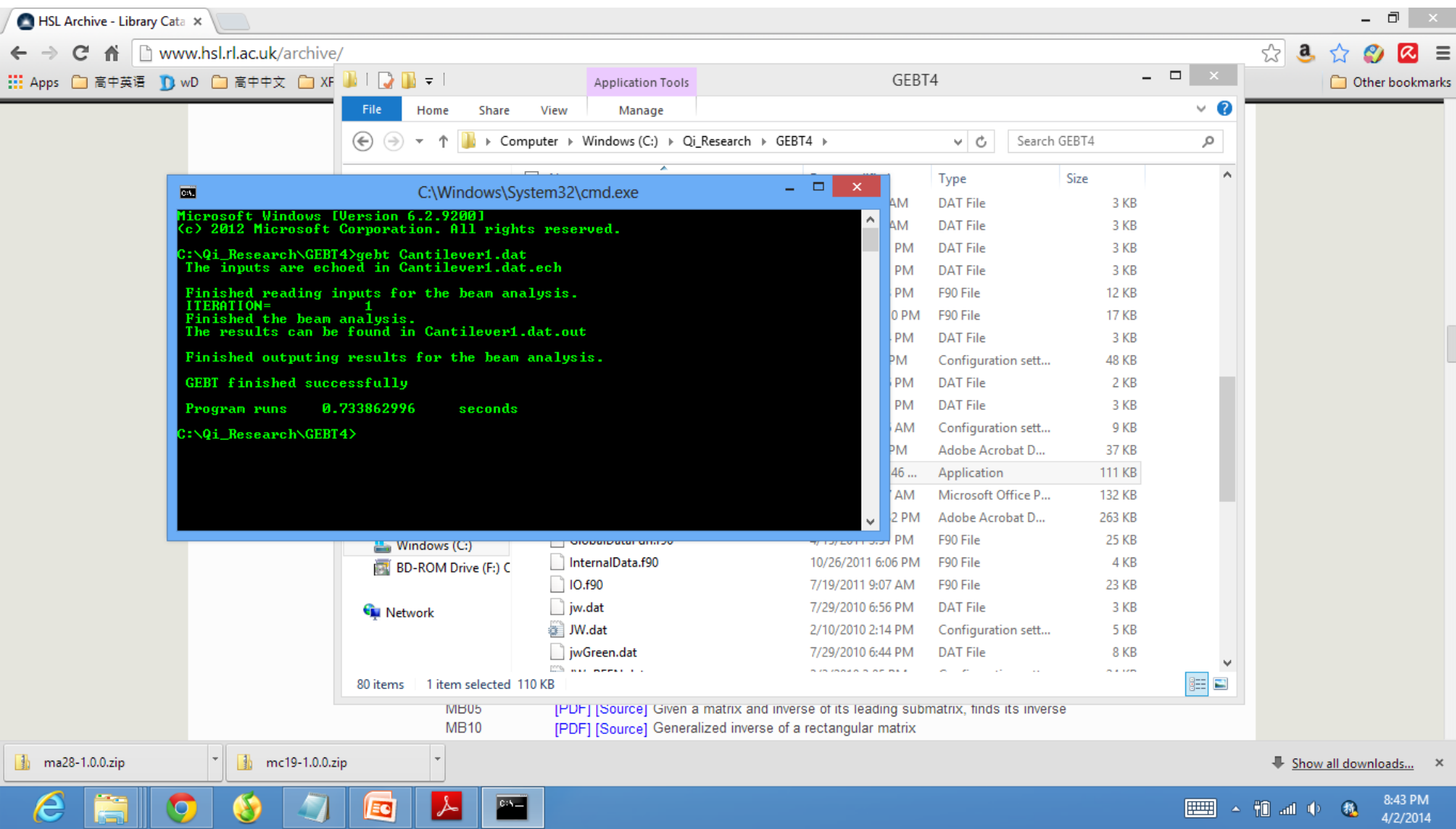
C:\Qi_Research\MA28>make -f MakeMA28
gfortran -O3 -c ddep.f
gfortran -O3 -c ma28.f
gfortran -O3 -c mc19.f
gfortran -O3 -shared ddep.o ma28.o mc19.o -o MA28.dll

C:\Qi_Research\MA28>
```

The taskbar at the bottom of the screen shows the Start button, several application icons (including Internet Explorer, Google Chrome, and a file explorer), and the system clock indicating 8:42 PM on 4/2/2014.

Step 4: Running GEBT

- 4.1 The best way to run GEBT is in the command window. Launch a command window in the “..\GEBT4” folder.
- 4.2 Type “gebt ‘input_file_name.dat’” in the command line, then click “enter”. In this example, the input file is “Cantilever1.dat”, which is included in the download package.



Step 5: Running PostGEBT

- 5.1 Two new files, “Cantilever1.dat.ech” and “Cantilever1.dat.out” for this case, will be generated which showed the analysis information and results, respectively.
- 5.2 Now you can run PostGEBT to visualize the results.