Parametric NAFEMS LE10 benchmark with hex elements

Comparison of resource consumption for different FEA programs

Contents

1   Architecture

Date	Thu Sep 28 15:48:01 UTC 2023
Host	Linux ip-172-31-44-208 6.2.0-1012-aws #12~22.04.1-Ubuntu SMP Thu Sep 7 14:01:24 UTC 2023 x86_64 x86_64 x86_64 GNU/Linux
CPU	Intel(R) Xeon(R) Platinum 8259CL CPU @ 2.50GHz
Number	2
Memory	16066232 kB

Figure 1: Architecture from `lstopo`

2 Codes & versions

2.1 aster

```
<INFO> Version exploitation 14.6.0 - 11/06/2020 - rev. b3490fa3b76c
```

2.2 calculix

```
This is Version 2.21
```

2.3 feenox

```
FeenoX v0.3.220-geb7bd44
a cloud-first free no-fee no-X uniX-like finite-element(ish) computational engineering tool

Last commit date   : Thu Sep 28 08:11:45 2023 -0300
Build date         : Thu Sep 28 13:47:20 2023 +0000
Build architecture : linux-gnu x86_64
Compiler version   : gcc (Ubuntu 11.4.0-1ubuntu1~22.04) 11.4.0
Compiler expansion : gcc -Wl,-Bsymbolic-functions -flto=auto -ffat-lto-objects -flto=auto -Wl,-z,relro -I/ ←↪
    usr/include/x86_64-linux-gnu/mpich -L/usr/lib/x86_64-linux-gnu -lmpich
Compiler flags     : -O3 -flto=auto -no-pie
Builder            : ubuntu@ip-172-31-44-208
GSL version        : 2.7.1
SUNDIALS version   : N/A
PETSc version      : Petsc Release Version 3.19.5, Aug 30, 2023
PETSc arch         : double-int32-release
PETSc options      : --download-eigen --download-hdf5 --download-hypre --download-metis --download-mumps -- ←↪
    download-parmetis --download-scalapack --download-slepc --with-64-bit-indices=no --with-debugging=no -- ←↪
    with-precision=double --with-scalar-type=real COPTFLAGS=-O3 CXXOPTFLAGS=-O3 FOPTFLAGS=-O3
SLEPc version      : SLEPc Release Version 3.19.1, unknown
```

2.4 reflex

```
Reflex Version: v1.12.3-1024-ga9e74e0ed
```

2.5 sparselizard

```
v.2022.05-53-g37a9d2b1
```

3   Reference solution

```
$ time feenox le10-ref.fee
sigma_y(D) = -5.3773 MPA (616323 degrees of freedom)
127.19user 3.46system 2:10.86elapsed 99%CPU (0avgtext+0avgdata 3485056maxresident)k
0inputs+0outputs (0major+1815753minor)pagefaults 0swaps
$
```
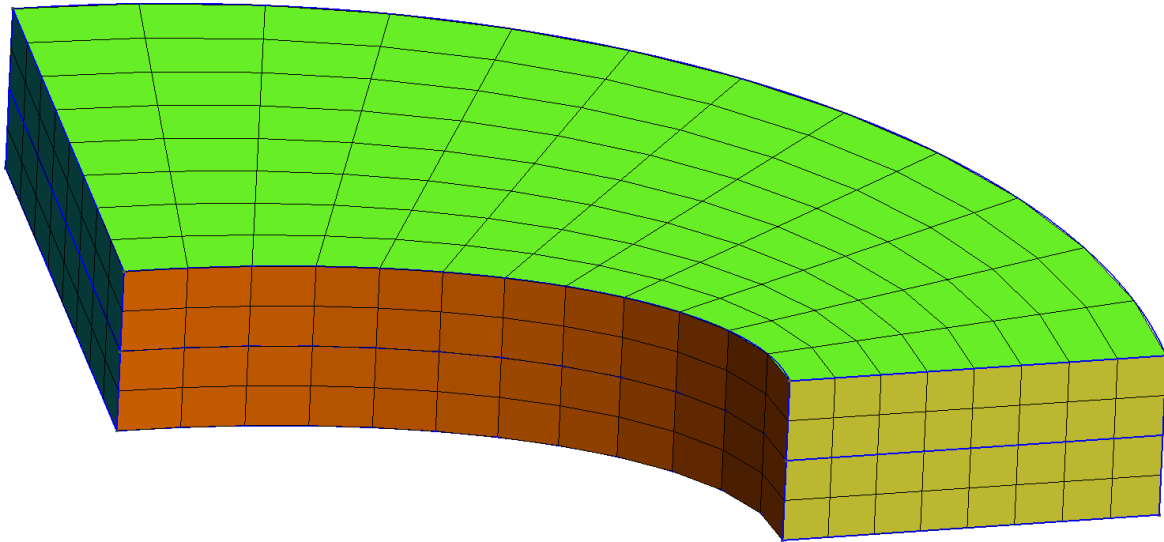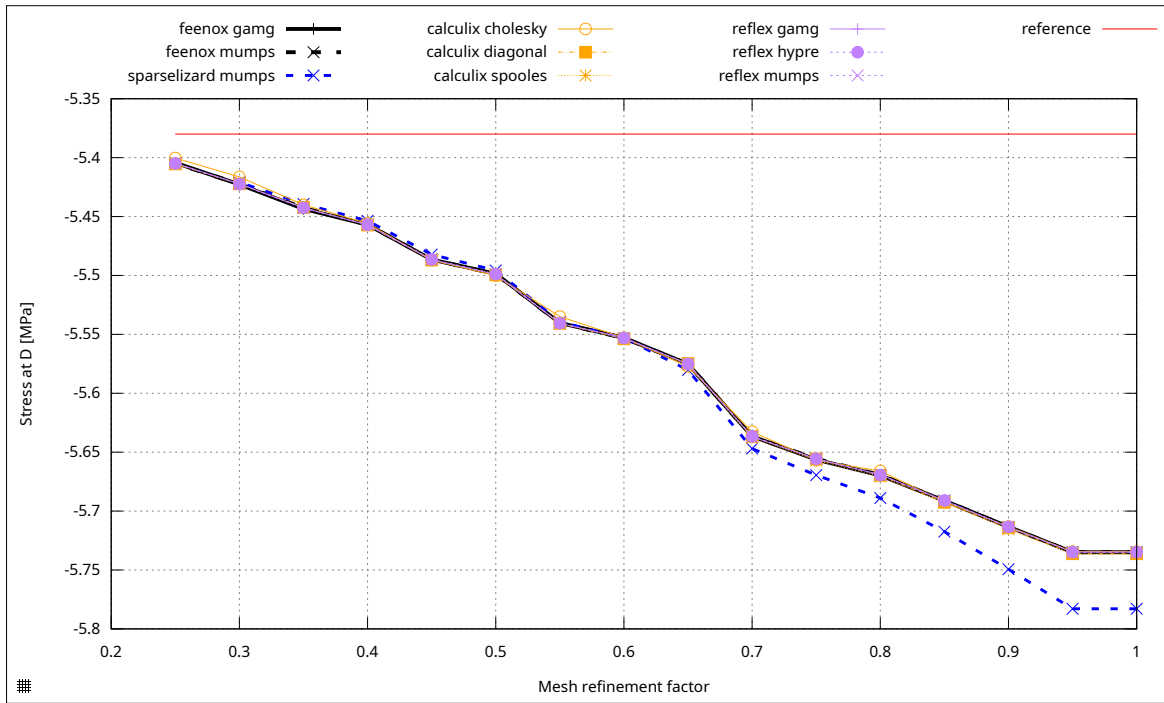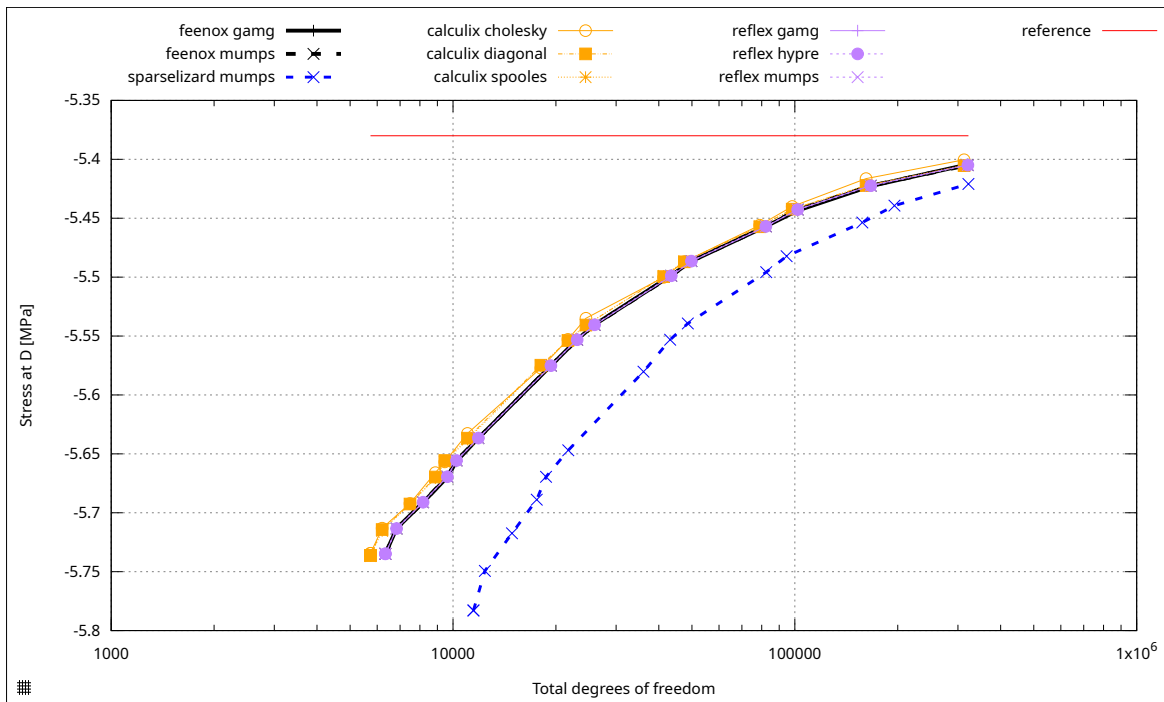

Figure 2: Coarser hex mesh for $c = 1$

4   Figures

(a)

(b)

Figure 3: Stress

(a)
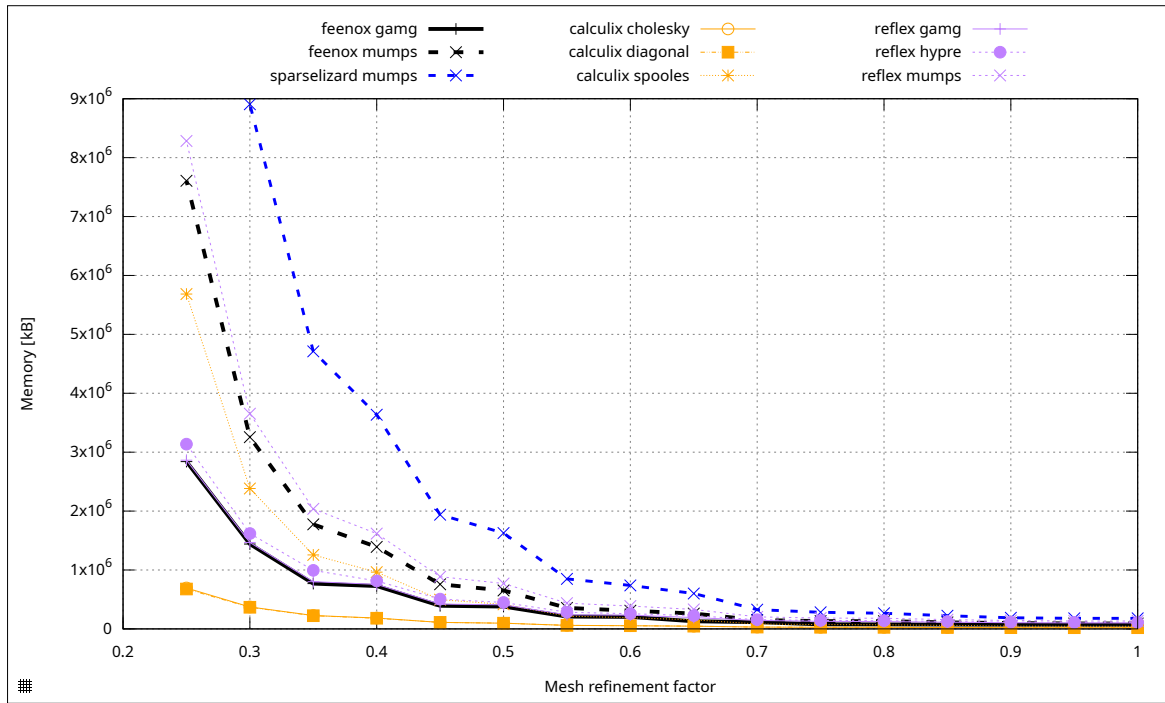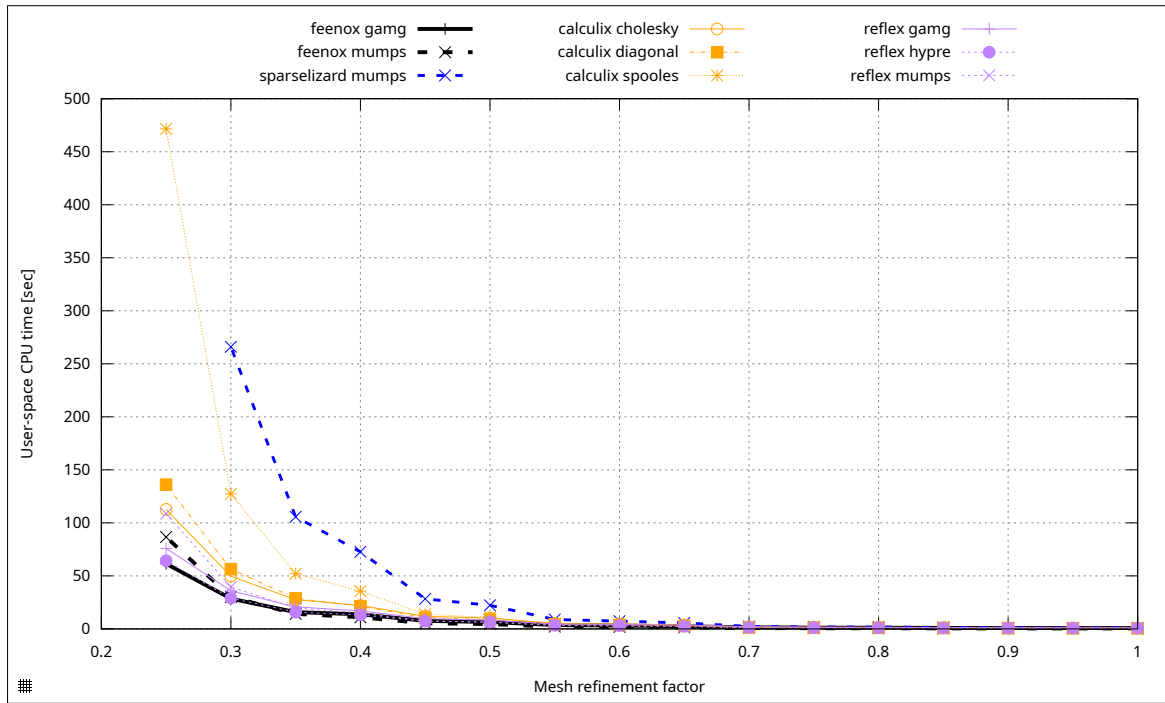

(b)

Figure 4: Memory

(a)

(b)

Figure 5: User

(a)

(b)
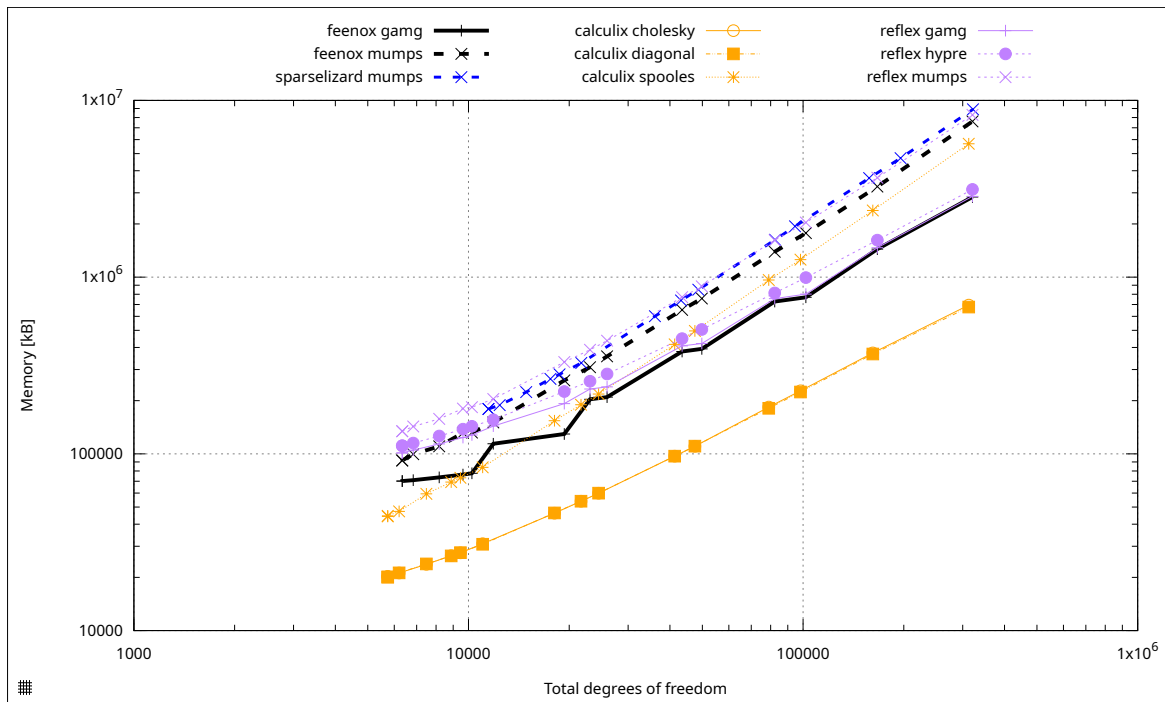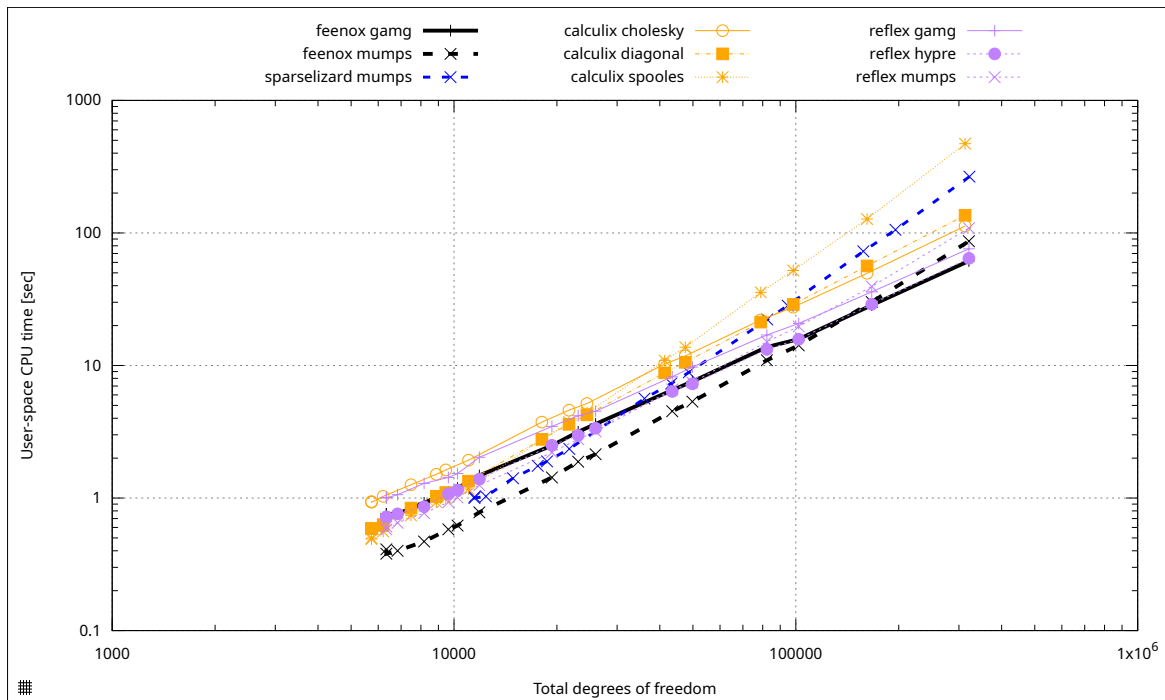
Figure 6: kernel

Parametric NAFEMS LE10 benchmark with hex elements
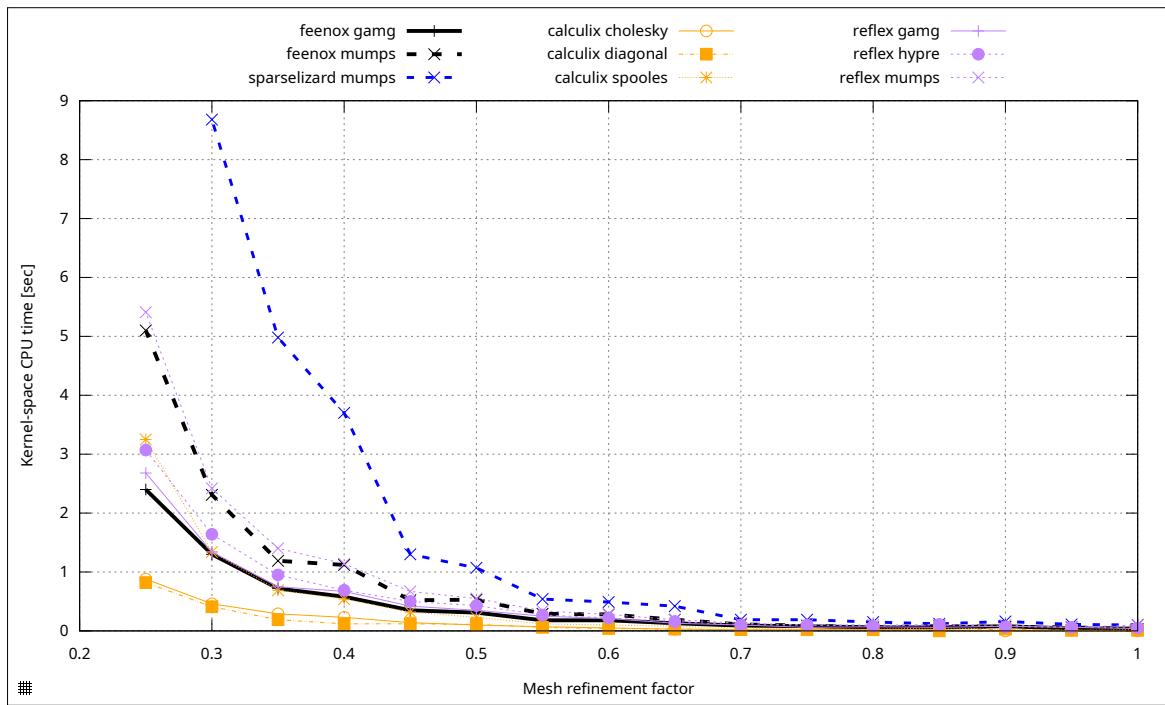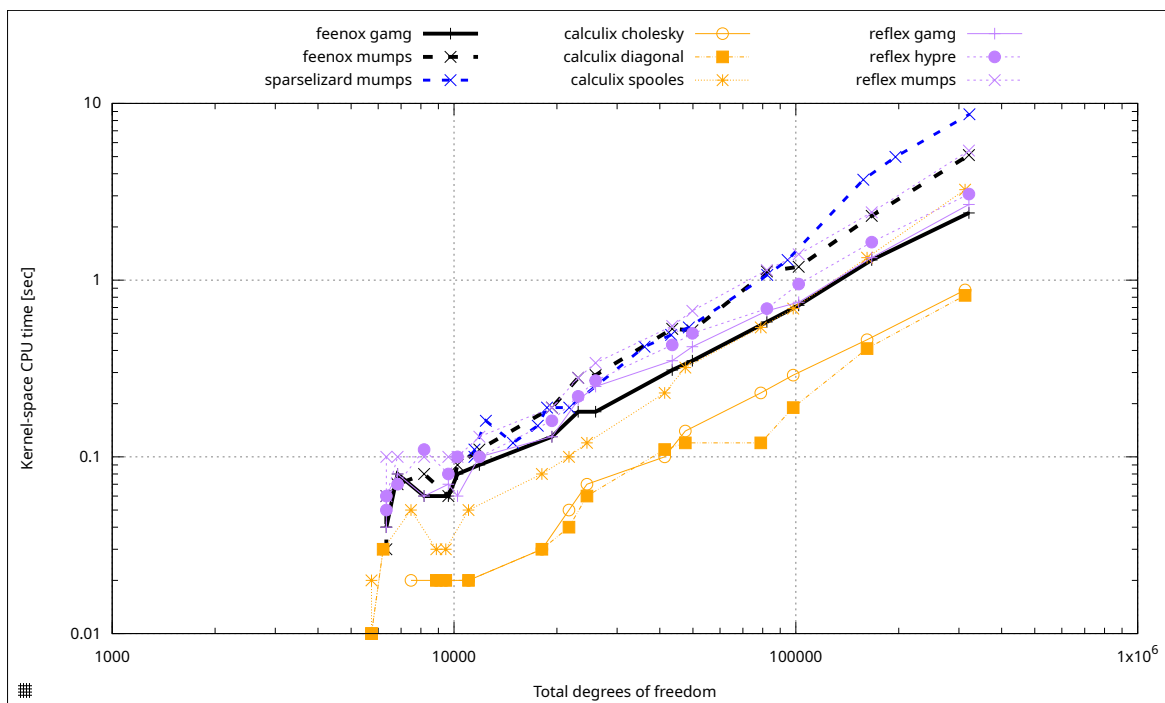
5 Tables

5.1 $c = 1$

Table 2: $c = 1$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	spooles	5,736	-5.737	0.5	0.0	0.5	0.04
calculix	diagonal	5,736	-5.736	0.6	0.0	0.6	0.02
feenox	mumps	6,339	-5.735	0.6	0.0	0.4	0.09
calculix	cholesky	5,736	-5.734	0.9	0.0	0.9	0.02
reflex	mumps	6,339	-5.735	0.9	0.1	0.6	0.13
feenox	gamg	6,339	-5.735	1.0	0.0	0.8	0.07
reflex	hypre	6,339	-5.735	1.0	0.1	0.7	0.11
sparselizar	mumps	11,475	-5.783	1.1	0.1	1.0	0.17
reflex	gamg	6,339	-5.735	1.2	0.0	1.0	0.10

Table 3: $c = 1$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	5,736	-5.734	0.9	0.0	0.9	0.02
calculix	diagonal	5,736	-5.736	0.6	0.0	0.6	0.02
calculix	spooles	5,736	-5.737	0.5	0.0	0.5	0.04
feenox	gamg	6,339	-5.735	1.0	0.0	0.8	0.07
feenox	mumps	6,339	-5.735	0.6	0.0	0.4	0.09
reflex	gamg	6,339	-5.735	1.2	0.0	1.0	0.10
reflex	hypre	6,339	-5.735	1.0	0.1	0.7	0.11
reflex	mumps	6,339	-5.735	0.9	0.1	0.6	0.13
sparselizar	mumps	11,475	-5.783	1.1	0.1	1.0	0.17

5.2 $c = 0.95$

Table 4: $c = 0.95$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	spooles	5,736	-5.737	0.5	0.0	0.5	0.04
calculix	diagonal	5,736	-5.736	0.6	0.0	0.6	0.02
feenox	mumps	6,339	-5.735	0.6	0.1	0.4	0.09
calculix	cholesky	5,736	-5.734	0.9	0.0	0.9	0.02
reflex	mumps	6,339	-5.735	0.9	0.1	0.6	0.13
feenox	gamg	6,339	-5.735	1.0	0.0	0.8	0.07
reflex	hypre	6,339	-5.735	1.0	0.1	0.7	0.11

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
sparselizar	mumps	11,475	-5.783	1.1	0.1	1.0	0.17
reflex	gamg	6,339	-5.735	1.2	0.1	1.0	0.10

Table 5: $c = 0.95$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	5,736	-5.734	0.9	0.0	0.9	0.02
calculix	diagonal	5,736	-5.736	0.6	0.0	0.6	0.02
calculix	spooles	5,736	-5.737	0.5	0.0	0.5	0.04
feenox	gamg	6,339	-5.735	1.0	0.0	0.8	0.07
feenox	mumps	6,339	-5.735	0.6	0.1	0.4	0.09
reflex	gamg	6,339	-5.735	1.2	0.1	1.0	0.10
reflex	hypre	6,339	-5.735	1.0	0.1	0.7	0.11
reflex	mumps	6,339	-5.735	0.9	0.1	0.6	0.13
sparselizar	mumps	11,475	-5.783	1.1	0.1	1.0	0.17

5.3 $c = 0.9$

Table 6: $c = 0.9$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	spooles	6,204	-5.715	0.6	0.0	0.6	0.05
calculix	diagonal	6,204	-5.714	0.7	0.0	0.6	0.02
feenox	mumps	6,837	-5.713	0.7	0.1	0.4	0.09
calculix	cholesky	6,204	-5.713	1.0	0.0	1.0	0.02
feenox	gamg	6,837	-5.713	1.0	0.1	0.8	0.07
reflex	hypre	6,837	-5.713	1.0	0.1	0.8	0.11
reflex	mumps	6,837	-5.713	1.0	0.1	0.7	0.14
sparselizar	mumps	12,393	-5.749	1.1	0.2	1.0	0.18
reflex	gamg	6,837	-5.714	1.3	0.1	1.1	0.10

Table 7: $c = 0.9$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	6,204	-5.713	1.0	0.0	1.0	0.02
calculix	diagonal	6,204	-5.714	0.7	0.0	0.6	0.02
calculix	spooles	6,204	-5.715	0.6	0.0	0.6	0.05
feenox	gamg	6,837	-5.713	1.0	0.1	0.8	0.07
feenox	mumps	6,837	-5.713	0.7	0.1	0.4	0.09

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
reflex	gamg	6,837	-5.714	1.3	0.1	1.1	0.10
reflex	hypre	6,837	-5.713	1.0	0.1	0.8	0.11
reflex	mumps	6,837	-5.713	1.0	0.1	0.7	0.14
sparselizar	mumps	12,393	-5.749	1.1	0.2	1.0	0.18

5.4 $c = 0.85$

Table 8: $c = 0.85$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	diagonal	7,484	-5.693	0.8	0.0	0.8	0.02
calculix	spooles	7,484	-5.693	0.8	0.1	0.7	0.06
feenox	mumps	8,175	-5.691	0.8	0.1	0.5	0.11
reflex	mumps	8,175	-5.691	1.1	0.1	0.8	0.15
feenox	gamg	8,175	-5.691	1.2	0.1	0.9	0.07
reflex	hypre	8,175	-5.691	1.2	0.1	0.9	0.12
calculix	cholesky	7,484	-5.692	1.3	0.0	1.3	0.02
sparselizar	mumps	14,877	-5.717	1.4	0.1	1.4	0.21
reflex	gamg	8,175	-5.691	1.6	0.1	1.3	0.11

Table 9: $c = 0.85$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	7,484	-5.692	1.3	0.0	1.3	0.02
calculix	diagonal	7,484	-5.693	0.8	0.0	0.8	0.02
calculix	spooles	7,484	-5.693	0.8	0.1	0.7	0.06
feenox	gamg	8,175	-5.691	1.2	0.1	0.9	0.07
feenox	mumps	8,175	-5.691	0.8	0.1	0.5	0.11
reflex	gamg	8,175	-5.691	1.6	0.1	1.3	0.11
reflex	hypre	8,175	-5.691	1.2	0.1	0.9	0.12
reflex	mumps	8,175	-5.691	1.1	0.1	0.8	0.15
sparselizar	mumps	14,877	-5.717	1.4	0.1	1.4	0.21

5.5 $c = 0.8$

Table 10: $c = 0.8$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	9,627	-5.669	0.8	0.1	0.6	0.13

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Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	spooles	8,878	-5.671	1.0	0.0	0.9	0.07
calculix	diagonal	8,878	-5.670	1.1	0.0	1.0	0.03
reflex	mumps	9,627	-5.669	1.2	0.1	0.9	0.17
feenox	gamg	9,627	-5.670	1.4	0.1	1.1	0.07
reflex	hypre	9,627	-5.669	1.4	0.1	1.1	0.13
calculix	cholesky	8,878	-5.666	1.5	0.0	1.5	0.03
reflex	gamg	9,627	-5.669	1.7	0.1	1.4	0.12
sparselizar	mumps	17,577	-5.689	1.8	0.1	1.8	0.25

Table 11: $c = 0.8$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	8,878	-5.666	1.5	0.0	1.5	0.03
calculix	diagonal	8,878	-5.670	1.1	0.0	1.0	0.03
calculix	spooles	8,878	-5.671	1.0	0.0	0.9	0.07
feenox	gamg	9,627	-5.670	1.4	0.1	1.1	0.07
reflex	gamg	9,627	-5.669	1.7	0.1	1.4	0.12
feenox	mumps	9,627	-5.669	0.8	0.1	0.6	0.13
reflex	hypre	9,627	-5.669	1.4	0.1	1.1	0.13
reflex	mumps	9,627	-5.669	1.2	0.1	0.9	0.17
sparselizar	mumps	17,577	-5.689	1.8	0.1	1.8	0.25

5.6 $c = 0.75$

Table 12: $c = 0.75$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	10,239	-5.656	0.9	0.1	0.6	0.13
calculix	spooles	9,460	-5.657	1.0	0.0	1.0	0.07
calculix	diagonal	9,460	-5.656	1.1	0.0	1.1	0.03
reflex	mumps	10,239	-5.656	1.3	0.1	1.0	0.18
reflex	hypre	10,239	-5.656	1.4	0.1	1.1	0.14
feenox	gamg	10,239	-5.656	1.5	0.1	1.2	0.07
calculix	cholesky	9,460	-5.657	1.6	0.0	1.6	0.03
reflex	gamg	10,239	-5.656	1.8	0.1	1.5	0.12
sparselizar	mumps	18,711	-5.669	2.0	0.2	1.9	0.27

Table 13: $c = 0.75$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	9,460	-5.657	1.6	0.0	1.6	0.03
calculix	diagonal	9,460	-5.656	1.1	0.0	1.1	0.03
calculix	spooles	9,460	-5.657	1.0	0.0	1.0	0.07
feenox	gamg	10,239	-5.656	1.5	0.1	1.2	0.07
reflex	gamg	10,239	-5.656	1.8	0.1	1.5	0.12
feenox	mumps	10,239	-5.656	0.9	0.1	0.6	0.13
reflex	hypre	10,239	-5.656	1.4	0.1	1.1	0.14
reflex	mumps	10,239	-5.656	1.3	0.1	1.0	0.18
sparselizar	mumps	18,711	-5.669	2.0	0.2	1.9	0.27

5.7 $c = 0.7$

Table 14: $c = 0.7$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	11,862	-5.637	1.1	0.1	0.8	0.14
calculix	spooles	11,025	-5.638	1.2	0.1	1.2	0.08
calculix	diagonal	11,025	-5.637	1.4	0.0	1.3	0.03
reflex	mumps	11,862	-5.637	1.6	0.1	1.2	0.19
reflex	hypre	11,862	-5.637	1.7	0.1	1.4	0.15
feenox	gamg	11,862	-5.637	1.8	0.1	1.5	0.11
calculix	cholesky	11,025	-5.633	1.9	0.0	1.9	0.03
reflex	gamg	11,862	-5.637	2.3	0.1	2.0	0.14
sparselizar	mumps	21,735	-5.647	2.4	0.2	2.4	0.31

Table 15: $c = 0.7$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	11,025	-5.633	1.9	0.0	1.9	0.03
calculix	diagonal	11,025	-5.637	1.4	0.0	1.3	0.03
calculix	spooles	11,025	-5.638	1.2	0.1	1.2	0.08
feenox	gamg	11,862	-5.637	1.8	0.1	1.5	0.11
feenox	mumps	11,862	-5.637	1.1	0.1	0.8	0.14
reflex	gamg	11,862	-5.637	2.3	0.1	2.0	0.14
reflex	hypre	11,862	-5.637	1.7	0.1	1.4	0.15
reflex	mumps	11,862	-5.637	1.6	0.1	1.2	0.19
sparselizar	mumps	21,735	-5.647	2.4	0.2	2.4	0.31

5.8 $c = 0.65$

Table 16: $c = 0.65$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	19,335	-5.575	1.8	0.2	1.4	0.25
reflex	mumps	19,335	-5.575	2.6	0.2	2.2	0.32
calculix	diagonal	18,072	-5.575	2.8	0.0	2.8	0.04
feenox	gamg	19,335	-5.575	2.8	0.1	2.5	0.12
calculix	spooles	18,072	-5.576	2.9	0.1	2.8	0.15
reflex	hypre	19,335	-5.575	2.9	0.2	2.5	0.21
calculix	cholesky	18,072	-5.577	3.8	0.0	3.7	0.04
reflex	gamg	19,335	-5.575	3.8	0.1	3.5	0.18
sparselizar	mumps	36,075	-5.580	5.8	0.4	5.6	0.57

Table 17: $c = 0.65$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	18,072	-5.577	3.8	0.0	3.7	0.04
calculix	diagonal	18,072	-5.575	2.8	0.0	2.8	0.04
feenox	gamg	19,335	-5.575	2.8	0.1	2.5	0.12
calculix	spooles	18,072	-5.576	2.9	0.1	2.8	0.15
reflex	gamg	19,335	-5.575	3.8	0.1	3.5	0.18
reflex	hypre	19,335	-5.575	2.9	0.2	2.5	0.21
feenox	mumps	19,335	-5.575	1.8	0.2	1.4	0.25
reflex	mumps	19,335	-5.575	2.6	0.2	2.2	0.32
sparselizar	mumps	36,075	-5.580	5.8	0.4	5.6	0.57

5.9 $c = 0.6$

Table 18: $c = 0.6$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	23,079	-5.553	2.4	0.3	1.9	0.29
reflex	mumps	23,079	-5.553	3.3	0.3	2.8	0.37
reflex	hypre	23,079	-5.553	3.4	0.2	3.0	0.25
feenox	gamg	23,079	-5.553	3.5	0.2	3.2	0.19
calculix	diagonal	21,692	-5.554	3.6	0.0	3.6	0.05
calculix	spooles	21,692	-5.554	3.9	0.1	3.7	0.18
reflex	gamg	23,079	-5.553	4.6	0.2	4.2	0.22
calculix	cholesky	21,692	-5.553	4.7	0.1	4.6	0.05

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
sparselizar	mumps	43,173	-5.553	7.5	0.5	7.3	0.70

Table 19: $c = 0.6$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	21,692	-5.553	4.7	0.1	4.6	0.05
calculix	diagonal	21,692	-5.554	3.6	0.0	3.6	0.05
calculix	spooles	21,692	-5.554	3.9	0.1	3.7	0.18
feenox	gamg	23,079	-5.553	3.5	0.2	3.2	0.19
reflex	gamg	23,079	-5.553	4.6	0.2	4.2	0.22
reflex	hypre	23,079	-5.553	3.4	0.2	3.0	0.25
feenox	mumps	23,079	-5.553	2.4	0.3	1.9	0.29
reflex	mumps	23,079	-5.553	3.3	0.3	2.8	0.37
sparselizar	mumps	43,173	-5.553	7.5	0.5	7.3	0.70

5.10 $c = 0.55$

Table 20: $c = 0.55$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	25,953	-5.540	2.6	0.3	2.1	0.34
reflex	mumps	25,953	-5.540	3.7	0.3	3.2	0.42
reflex	hypre	25,953	-5.540	3.8	0.3	3.4	0.27
feenox	gamg	25,953	-5.540	4.0	0.2	3.6	0.20
calculix	diagonal	24,484	-5.541	4.3	0.1	4.2	0.06
calculix	spooles	24,484	-5.541	4.5	0.1	4.4	0.21
reflex	gamg	25,953	-5.541	5.0	0.2	4.5	0.23
calculix	cholesky	24,484	-5.535	5.2	0.1	5.2	0.06
sparselizar	mumps	48,633	-5.539	9.1	0.5	8.9	0.81

Table 21: $c = 0.55$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	24,484	-5.535	5.2	0.1	5.2	0.06
calculix	diagonal	24,484	-5.541	4.3	0.1	4.2	0.06
feenox	gamg	25,953	-5.540	4.0	0.2	3.6	0.20
calculix	spooles	24,484	-5.541	4.5	0.1	4.4	0.21
reflex	gamg	25,953	-5.541	5.0	0.2	4.5	0.23
reflex	hypre	25,953	-5.540	3.8	0.3	3.4	0.27

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	25,953	-5.540	2.6	0.3	2.1	0.34
reflex	mumps	25,953	-5.540	3.7	0.3	3.2	0.42
sparselizard	mumps	48,633	-5.539	9.1	0.5	8.9	0.81

5.11 $c = 0.5$

Table 22: $c = 0.5$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	43,491	-5.499	5.2	0.5	4.5	0.62
feenox	gamg	43,491	-5.499	7.0	0.3	6.5	0.36
reflex	hypre	43,491	-5.499	7.0	0.4	6.4	0.43
reflex	mumps	43,491	-5.499	7.3	0.6	6.6	0.73
reflex	gamg	43,491	-5.499	8.8	0.3	8.2	0.39
calculix	diagonal	41,328	-5.500	8.9	0.1	8.8	0.09
calculix	cholesky	41,328	-5.500	10.3	0.1	10.2	0.09
calculix	spooles	41,328	-5.499	11.1	0.2	10.9	0.40
sparselizard	mumps	82,467	-5.496	22.8	1.1	22.2	1.55

Table 23: $c = 0.5$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	41,328	-5.500	10.3	0.1	10.2	0.09
calculix	diagonal	41,328	-5.500	8.9	0.1	8.8	0.09
feenox	gamg	43,491	-5.499	7.0	0.3	6.5	0.36
reflex	gamg	43,491	-5.499	8.8	0.3	8.2	0.39
calculix	spooles	41,328	-5.499	11.1	0.2	10.9	0.40
reflex	hypre	43,491	-5.499	7.0	0.4	6.4	0.43
feenox	mumps	43,491	-5.499	5.2	0.5	4.5	0.62
reflex	mumps	43,491	-5.499	7.3	0.6	6.6	0.73
sparselizard	mumps	82,467	-5.496	22.8	1.1	22.2	1.55

5.12 $c = 0.45$

Table 24: $c = 0.45$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	49,815	-5.486	6.0	0.5	5.3	0.72
reflex	hypre	49,815	-5.486	8.0	0.5	7.3	0.48

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Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	gamg	49,815	-5.487	8.1	0.3	7.6	0.37
reflex	mumps	49,815	-5.486	8.3	0.7	7.4	0.85
reflex	gamg	49,815	-5.487	10.3	0.4	9.7	0.40
calculix	diagonal	47,492	-5.487	10.7	0.1	10.6	0.11
calculix	cholesky	47,492	-5.487	12.0	0.1	11.8	0.11
calculix	spooles	47,492	-5.487	14.1	0.3	13.7	0.47
sparselizar	mumps	94,605	-5.482	29.0	1.3	28.3	1.85

Table 25: $c = 0.45$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	cholesky	47,492	-5.487	12.0	0.1	11.8	0.11
calculix	diagonal	47,492	-5.487	10.7	0.1	10.6	0.11
feenox	gamg	49,815	-5.487	8.1	0.3	7.6	0.37
reflex	gamg	49,815	-5.487	10.3	0.4	9.7	0.40
calculix	spooles	47,492	-5.487	14.1	0.3	13.7	0.47
reflex	hypre	49,815	-5.486	8.0	0.5	7.3	0.48
feenox	mumps	49,815	-5.486	6.0	0.5	5.3	0.72
reflex	mumps	49,815	-5.486	8.3	0.7	7.4	0.85
sparselizar	mumps	94,605	-5.482	29.0	1.3	28.3	1.85

5.13 $c = 0.4$

Table 26: $c = 0.4$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	82,263	-5.457	12.3	1.1	10.9	1.33
reflex	hypre	82,263	-5.457	14.1	0.7	13.2	0.78
feenox	gamg	82,263	-5.457	14.6	0.6	13.8	0.69
reflex	mumps	82,263	-5.457	16.4	1.1	15.1	1.54
reflex	gamg	82,263	-5.457	17.9	0.7	17.0	0.72
calculix	diagonal	78,960	-5.457	21.4	0.1	21.2	0.17
calculix	cholesky	78,960	-5.456	22.3	0.2	22.1	0.18
calculix	spooles	78,960	-5.457	36.2	0.5	35.6	0.92
sparselizar	mumps	157,563	-5.454	75.4	3.7	72.7	3.47

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Table 27: $c = 0.4$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	diagonal	78,960	-5.457	21.4	0.1	21.2	0.17
calculix	cholesky	78,960	-5.456	22.3	0.2	22.1	0.18
feenox	gamg	82,263	-5.457	14.6	0.6	13.8	0.69
reflex	gamg	82,263	-5.457	17.9	0.7	17.0	0.72
reflex	hypre	82,263	-5.457	14.1	0.7	13.2	0.78
calculix	spooles	78,960	-5.457	36.2	0.5	35.6	0.92
feenox	mumps	82,263	-5.457	12.3	1.1	10.9	1.33
reflex	mumps	82,263	-5.457	16.4	1.1	15.1	1.54
sparselizar	mumps	157,563	-5.454	75.4	3.7	72.7	3.47

5.14 $c = 0.35$

Table 28: $c = 0.35$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	mumps	101,931	-5.443	15.6	1.2	14.2	1.69
feenox	gamg	101,931	-5.443	16.7	0.7	15.8	0.73
reflex	hypre	101,931	-5.443	16.9	0.9	15.8	0.95
reflex	mumps	101,931	-5.443	21.3	1.4	19.7	1.94
reflex	gamg	101,931	-5.443	21.7	0.8	20.8	0.76
calculix	cholesky	98,236	-5.440	27.8	0.3	27.5	0.22
calculix	diagonal	98,236	-5.442	29.1	0.2	28.9	0.21
calculix	spooles	98,236	-5.443	52.8	0.7	52.1	1.20
sparselizar	mumps	195,615	-5.439	109.5	5.0	105.7	4.49

Table 29: $c = 0.35$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	diagonal	98,236	-5.442	29.1	0.2	28.9	0.21
calculix	cholesky	98,236	-5.440	27.8	0.3	27.5	0.22
feenox	gamg	101,931	-5.443	16.7	0.7	15.8	0.73
reflex	gamg	101,931	-5.443	21.7	0.8	20.8	0.76
reflex	hypre	101,931	-5.443	16.9	0.9	15.8	0.95
calculix	spooles	98,236	-5.443	52.8	0.7	52.1	1.20
feenox	mumps	101,931	-5.443	15.6	1.2	14.2	1.69
reflex	mumps	101,931	-5.443	21.3	1.4	19.7	1.94
sparselizar	mumps	195,615	-5.439	109.5	5.0	105.7	4.49

5.15 $c = 0.3$

Table 30: $c = 0.3$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
feenox	gamg	166,719	-5.423	30.0	1.3	28.5	1.37
reflex	hypre	166,719	-5.422	30.8	1.6	29.0	1.54
feenox	mumps	166,719	-5.422	32.6	2.3	30.1	3.10
reflex	gamg	166,719	-5.422	37.5	1.3	35.9	1.40
reflex	mumps	166,719	-5.422	42.1	2.4	39.5	3.48
calculix	cholesky	161,572	-5.416	50.1	0.5	49.6	0.36
calculix	diagonal	161,572	-5.422	56.8	0.4	56.4	0.35
calculix	spooles	161,572	-5.422	128.7	1.3	127.3	2.27
sparselizar	mumps	321,975	-5.421	272.8	8.7	266.0	8.49

Table 31: $c = 0.3$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	diagonal	161,572	-5.422	56.8	0.4	56.4	0.35
calculix	cholesky	161,572	-5.416	50.1	0.5	49.6	0.36
feenox	gamg	166,719	-5.423	30.0	1.3	28.5	1.37
reflex	gamg	166,719	-5.422	37.5	1.3	35.9	1.40
reflex	hypre	166,719	-5.422	30.8	1.6	29.0	1.54
calculix	spooles	161,572	-5.422	128.7	1.3	127.3	2.27
feenox	mumps	166,719	-5.422	32.6	2.3	30.1	3.10
reflex	mumps	166,719	-5.422	42.1	2.4	39.5	3.48
sparselizar	mumps	321,975	-5.421	272.8	8.7	266.0	8.49

5.16 $c = 0.25$

Table 32: $c = 0.25$ sorted by wall time

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
sparselizar	mumps	624,195	-nan	47.3	9.9	41.1	5.00
feenox	gamg	320,835	-5.404	64.1	2.4	61.5	2.71
reflex	hypre	320,835	-5.405	67.6	3.1	64.3	2.99
reflex	gamg	320,835	-5.405	78.8	2.7	75.9	2.73
feenox	mumps	320,835	-5.405	92.0	5.1	86.6	7.25
calculix	cholesky	312,672	-5.400	113.6	0.9	112.7	0.66
reflex	mumps	320,835	-5.405	114.3	5.4	108.7	7.90
calculix	diagonal	312,672	-5.405	136.8	0.8	136.0	0.65

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Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	spooles	312,672	-5.405	474.8	3.2	471.5	5.42

Table 33: $c = 0.25$ sorted by memory

Program	Solver	DOFs	σ_y	Wall [s]	Kernel [s]	User [s]	Memory [Gb]
calculix	diagonal	312,672	-5.405	136.8	0.8	136.0	0.65
calculix	cholesky	312,672	-5.400	113.6	0.9	112.7	0.66
feenox	gamg	320,835	-5.404	64.1	2.4	61.5	2.71
reflex	gamg	320,835	-5.405	78.8	2.7	75.9	2.73
reflex	hypre	320,835	-5.405	67.6	3.1	64.3	2.99
sparselizar	mumps	624,195	-nan	47.3	9.9	41.1	5.00
calculix	spooles	312,672	-5.405	474.8	3.2	471.5	5.42
feenox	mumps	320,835	-5.405	92.0	5.1	86.6	7.25
reflex	mumps	320,835	-5.405	114.3	5.4	108.7	7.90