Homework 4

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1 Question 1

See the attached LIZFCM Software Manual.

2 Question 2, 3, 4

```
20:46:51 with lizzy in ~/Homework/math-4610 at armin on  main [⇡$X!+?]
➜ make
mkdir -p dist
mkdir -p build
cc -Iinc -MMD -MP -Wall -c src/approx_derivative.c -o build/approx_derivative.o
cc -Iinc -MMD -MP -Wall -c src/lin.c -o build/lin.o
cc -Iinc -MMD -MP -Wall -c src/maceps.c -o build/maceps.o
cc -Iinc -MMD -MP -Wall -c src/matrix.c -o build/matrix.o
cc -Iinc -MMD -MP -Wall -c src/vector.c -o build/vector.o
mkdir -p lib
ar rcs lib/lizfcm.a build/*.o
ranlib lib/lizfcm.a
cc -Iinc -MMD -MP -Wall -lm test/main.c lib/lizfcm.a -o dist/lizfcm.test

20:46:54 with lizzy in ~/Homework/math-4610 at armin on  main [⇡$X!+?]
➜ ls lib
lizfcm.a
```

3 Question 5

```
18:38:11 with lizzy in ~/Homework/math-4610 at armin on ᚠ main [⇡$X!+?]
➜ ./dist/lizfcm.test
Basic Routines
smaceps(): 5.9604644775e-08
dmaceps(): 1.1102230246e-16
========
Norm, Distance
v: 3.000000,1.000000,-4.000000,1.000000,5.000000,-9.000000,3.000000,
w: -2.000000,7.000000,1.000000,-8.000000,-2.000000,8.000000,5.000000,
l1_norm(v): 26.000000
l2_norm(v): 11.916375
linf_norm(v): 5.000000
l1_dist(v, w): 51.000000
l2_dist(v, w): 22.561028
linf_dist(v, w): 9.000000
========
Derivative Approxs
f(x) = (x-1)/(x+1)
approx f'(1) w/ c.d.: 0.500000
approx f'(1) w/ fw.d.: 0.499750
approx f'(1) w/ bw.d.: 0.500250
========
Least Squares
v: 1.000000,2.000000,3.000000,4.000000,5.000000,
w: 2.000000,3.000000,4.000000,5.000000,6.000000,
least_squares_lin_reg(v, w): (1.000000)x + 1.000000
v: 1.000000,2.000000,3.000000,4.000000,5.000000,6.000000,7.000000,
w: 0.500000,3.000000,2.000000,3.500000,5.000000,6.000000,7.500000,
least_squares_lin_reg(v, w): (1.071429)x + -0.357143
========
LU Decomp
a = 93.000000,51.000000,27.000000,42.000000,-30.000000,28.000000,-44.000000,22.000000,-23.000000,-9.000000,
60.000000,-65.000000,8.000000,58.000000,-87.000000,-3.000000,-27.000000,-29.000000,60.000000,88.000000,
-3.000000,-69.000000,-9.000000,-57.000000,-60.000000,-33.000000,1.000000,22.000000,84.000000,-35.000000,
3.000000,74.000000,-12.000000,33.000000,90.000000,67.000000,-79.000000,-49.000000,-79.000000,79.000000,
-67.000000,28.000000,-93.000000,-36.000000,15.000000,-45.000000,72.000000,9.000000,-94.000000,-57.000000,
99.000000,-53.000000,-8.000000,-44.000000,32.000000,10.000000,-24.000000,-96.000000,-30.000000,-3.000000,
-22.000000,34.000000,-49.000000,76.000000,99.000000,47.000000,-77.000000,92.000000,72.000000,-33.000000,
2.000000,-81.000000,65.000000,87.000000,35.000000,86.000000,37.000000,-36.000000,75.000000,31.000000,
-15.000000,6.000000,71.000000,-1.000000,-17.000000,-95.000000,-5.000000,96.000000,49.000000,2.000000,
-88.000000,-23.000000,-5.000000,18.000000,-52.000000,-66.000000,-16.000000,-37.000000,62.000000,-44.000000,

u = 93.000000,51.000000,27.000000,42.000000,-30.000000,28.000000,-44.000000,22.000000,-23.000000,-9.000000,
0.000000,-97.903226,-9.419355,30.903226,-67.645161,-21.064516,1.387097,-43.193548,74.838710,93.806452,
0.000000,0.000000,-1.648764,-76.905766,-14.429654,-17.604942,-1.373641,52.425700,31.771005,-99.826689,
0.000000,0.000000,0.000000,979.550959,214.543165,262.291567,-60.032574,-712.238209,-405.108913,1349.390488,
0.000000,0.000000,0.000000,0.000000,-171.387162,-187.264725,336.638862,175.983302,-53.329096,-317.604701,
0.000000,0.000000,-0.000000,0.000000,-0.000000,-149.697147,359.273658,24.371689,-176.945841,-259.273955,
0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,-50.905324,212.296197,195.000653,-186.566483,
0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,812.233622,629.784008,-873.359206,
0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,-68.074943,27.433962,
0.000000,0.000000,-0.000000,0.000000,-0.000000,0.000000,0.000000,0.000000,0.000000,-204.442037,
```

```
l = 1.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,
0.645161,1.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,
-0.032258,0.687974,1.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,
0.032258,-0.739044,12.028577,1.000000,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000,
-0.720430,-0.661285,48.386091,3.813853,1.000000,0.000000,0.000000,0.000000,0.000000,0.000000,
1.064516,1.095881,16.023781,1.132912,-0.736494,1.000000,0.000000,0.000000,0.000000,0.000000,
-0.236559,-0.470511,28.533373,2.342764,0.179838,0.232263,1.000000,0.000000,0.000000,0.000000,
0.021505,0.838550,-43.861910,-3.382214,-1.079939,-0.105324,-3.435385,1.000000,0.000000,0.000000,
-0.161290,-0.145305,-44.873701,-3.512611,-0.434262,0.290835,4.767804,-1.229770,1.000000,0.000000,
-0.946237,-0.257990,-10.989009,-0.795674,0.500037,-0.427111,2.652376,-0.810860,-0.453673,1.000000,

(after following q8) b = 157.000000,63.000000,-159.000000,127.000000,-268.000000,-117.000000,239.000000,301.0
00000,91.000000,-251.000000,
========
Forward / Backward Substitution Solution to ax=b
b_fsub: 157.000000,-38.290323,-127.592751,1628.396483,-216.963520,-202.271597,169.825042,568.658425,-40.64098
2,-204.442037,
x_bsub: 1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,
Verifications
in row 0, solution = 1.000000, true value err=7.1054273576e-15
in row 1, solution = 1.000000, true value err=2.5757174171e-14
in row 2, solution = 1.000000, true value err=6.8833827527e-15
in row 3, solution = 1.000000, true value err=6.9944050551e-15
in row 4, solution = 1.000000, true value err=6.8833827527e-15
in row 5, solution = 1.000000, true value err=1.2101430968e-14
in row 6, solution = 1.000000, true value err=1.2212453271e-14
in row 7, solution = 1.000000, true value err=7.9936057773e-15
in row 8, solution = 1.000000, true value err=2.3092638912e-14
in row 9, solution = 1.000000, true value err=9.7699626167e-15
```

4 Question 6

See the LIZFCM Software Manual.

5 Question 7

See `src/matrix.c -> lu_decomp, fsubst, bsubst, solve_matrix`

6 Question 8

See `test/main.c -> lines 109 - 113` in correspondence to the run in Question 5

7 Question 9

See `test/main.c -> lines 118 - 121` in correspondence to the run in Question 5

8 Question 10

See the TOC on the first page of the LIZFCM Software Manual.