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Lab 8 Solving Ax = b

function v=rvect(m) %This gives us a random vector depending on the m value we input

v=fix(10\*rand(m,1)); %The fix is so that they are all whole numbers

function A = rmat(m,n) %This gives us a random matrix depending on the m and n value we %input

A = fix(10\*rand(m,n)); %The fix is so that they are all whole numbers

squared\_1 %Running squared\_1

y = squared\_2(0.1,10); %Running function squared\_2 with values

z = squared\_2(0.2,2); %Running function squared\_2 with values

dx = 0.3; %assigning variable dx with value 0.3

max = 3; %assigning variable max with value 3

w = squared\_2(dx,max); %Running function squared\_2 with values dx and max

rand('seed',8776) %Randomizing to my last four digits of b number

A = rmat(5,5) %Making a 5x5 random matrix

A = %Values for A

4 7 0 8 4

5 0 9 8 6

7 1 2 1 6

2 6 1 6 1

3 0 4 5 2

b = rvect(5) %Making a 5x1 random vector

b = %Values of b

6

5

8

2

7

rank(A) %Checking rank of A

ans = %Rank of A

5

**There is a solution for Ax=b because as long as the rank A is equal to the rank of [A b], then there is at least one solution, and in this case n is 5 so it has a unique solution**

A\_aug = [A b] %Putting matrix A and vector b together

A\_aug = %Value of A\_aug

4 7 0 8 4 6

5 0 9 8 6 5

7 1 2 1 6 8

2 6 1 6 1 2

3 0 4 5 2 7

R = rref(A\_aug) %Reduced row echelon form of A\_aug

R = %Value of R

1.0000 0 0 0 0 2.5656

0 1.0000 0 0 0 -1.4708

0 0 1.0000 0 0 -1.2692

0 0 0 1.0000 0 1.3636

0 0 0 0 1.0000 -1.2190

x\_rref = R(1:5,6) %Setting x\_rref to be the last column of R

x\_rref = %Value of x\_rref

2.5656

-1.4708

-1.2692

1.3636

-1.2190

A \* x\_rref %A times x\_rref gives b

ans = Value of A times x\_rref

6.0000

5.0000

8.0000

2.0000

7.0000

**Value of A times x\_rref gives us the same of value of b so it is correct**

b %Checking b

b = %Value of b

6

5

8

2

7

A\_inv = inv(A) %Setting A\_inv to be the inverse of A

A\_inv = %Value of A\_inv

-0.1544 -0.2451 0.1821 0.1497 0.4231

-0.1508 0.0862 0.0615 0.3323 -0.3077

-0.2692 0.1538 0.0385 0.3077 -0.1923

0.2036 -0.0687 -0.1205 -0.2174 0.2692

0.2610 0.2318 -0.0487 -0.2964 -0.4231

A \* A\_inv %Multiplying A \* A\_inv which should give I

ans = %Value of A \* A\_inv which has ones for pivot so it is I

1.0000 0.0000 0.0000 0.0000 -0.0000

-0.0000 1.0000 -0.0000 -0.0000 0.0000

0 0 1.0000 0.0000 0

-0.0000 0.0000 0.0000 1.0000 -0.0000

-0.0000 -0.0000 0.0000 0.0000 1.0000

**A times inverse of A gives us a value of 1 at each pivot, which is the same as I so it is the inverse**

A\_inv \* b %Multiplying A\_inv and b to get x value

ans = %Value of A\_inv times b

2.5656

-1.4708

-1.2692

1.3636

-1.2190

**The inverse of A times b gives us the same value as x\_rref so our inverse of A is the true inverse of A**

x\_rref %Checking value of x\_rref

x\_rref = %Values of x\_rref

2.5656

-1.4708

-1.2692

1.3636

-1.2190

x\_inv = A\_inv \* b %setting x\_inv to be solution of A\_inv times b

x\_inv = %Value of x\_inv which is same value of x\_rref

2.5656

-1.4708

-1.2692

1.3636

-1.2190

**Got the same value for x\_inv as x\_rref**

A %Checking value of A

A = %Value of A

4 7 0 8 4

5 0 9 8 6

7 1 2 1 6

2 6 1 6 1

3 0 4 5 2

rank(A) %Checking rank of value A

ans = %Value of rank A

5

A1 = A(1:5,1:4) %Setting A1 to be first four columns of A

A1 = %Value of A1

4 7 0 8

5 0 9 8

7 1 2 1

2 6 1 6

3 0 4 5

A1(1,5) = -19 %Adding value to space (1,5) of A1

A1 = %Value of A1

4 7 0 8 -19

5 0 9 8 0

7 1 2 1 0

2 6 1 6 0

3 0 4 5 0

A1(2,5) = -22 %Adding value to space (2,5) of A1

A1 = %Value of A1

4 7 0 8 -19

5 0 9 8 -22

7 1 2 1 0

2 6 1 6 0

3 0 4 5 0

A1(3,5) = -11 %Adding value to space (3,5) of A1

A1 = %Value of A1

4 7 0 8 -19

5 0 9 8 -22

7 1 2 1 -11

2 6 1 6 0

3 0 4 5 0

A1(4,5) = -15 %Adding value to space (4,5) of A1

A1 = %Value of A1

4 7 0 8 -19

5 0 9 8 -22

7 1 2 1 -11

2 6 1 6 -15

3 0 4 5 0

A1(5,5) = -12 %Adding value to space (5,5) of A1

A1 = %Value of A1

4 7 0 8 -19

5 0 9 8 -22

7 1 2 1 -11

2 6 1 6 -15

3 0 4 5 -12

**I made the fifth column by adding the row and then putting the negative version of that number in the fifth column. So for the first row it was 4 plus 7 plus 8 which is 19, so I put -19 in the space (1,5) of A1 matrix**

rank(A1) %Checking rank of A1

ans = %Rank of A1

4

A\_aug1 = [A1 b] %Putting matrix A1 and vector b together

A\_aug1 = %Value of A\_aug1

4 7 0 8 -19 6

5 0 9 8 -22 5

7 1 2 1 -11 8

2 6 1 6 -15 2

3 0 4 5 -12 7

R1 = rref(A\_aug1) %Reduced row echelon form of A\_aug1

R1 = %Value of R1

1 0 0 0 -1 0

0 1 0 0 -1 0

0 0 1 0 -1 0

0 0 0 1 -1 0

0 0 0 0 0 1

**There is no solution as on row 5, the first 5 are 0 and the sixth spot is a 1 which can’t work out**

x1 = rvect(5) %Making a 5x1 random vector

x1 = %Value of x1

2

4

0

4

7

b1 = A1 \* x1 %Multiply A1 and x1

b1 = %Value of b1

-65

-112

-55

-53

-58

**This b1 will give us a solution because now we changed our b to fit with this new x**

A\_aug2 = [A1 b1] %Putting matrix A1 and vector b1 together

A\_aug2 = %Value of A\_aug2

4 7 0 8 -19 -65

5 0 9 8 -22 -112

7 1 2 1 -11 -55

2 6 1 6 -15 -53

3 0 4 5 -12 -58

R2 = rref(A\_aug2) %Reduced row echelon form of A\_aug2

R2 = %Value of R2

1 0 0 0 -1 -5

0 1 0 0 -1 -3

0 0 1 0 -1 -7

0 0 0 1 -1 -3

0 0 0 0 0 0

R2\_rref = R2(1:5,6) %Value of 6th column of R2

R2\_rref = %Value of R2\_rref

-5

-3

-7

-3

0

A1 \* R2\_rref %A1 times R2\_rref

ans = %Value of A1 times R2\_rref

-65

-112

-55

-53

-58

**R2 is a solution as when multiplied by A1 we get b1**

b1 %Checking b1

b1 = %Value of b1

-65

-112

-55

-53

-58

A1 \* x1 %A1 times x1

ans = %Value of A1 times x1

-65

-112

-55

-53

-58

**x1 is a solution as when multiplied by A1 it gives us b1, I did not get two values**

b1 %Checking b1

b1 = %Value of b1

-65

-112

-55

-53

-58

Clear %Clear workspace

A = rmat(3,5) %Making a 3x5 random matrix

A = %Value of A

8 1 9 0 5

4 3 2 8 0

2 2 3 3 5

b = rvect(3) %Making a 3x1 random vector

b = %Value of b

3

5

1

rank(A) %Checking rank of A

ans = %Value of rank of A

3

**There is a solution for Ax = b as the rank for A and [A b] are both 3, but n is 5 so there are an infinite amount of solutions**

A\_aug = [A b] %Putting matrix A and vector b together

A\_aug = %Value of A\_aug

8 1 9 0 5 3

4 3 2 8 0 5

2 2 3 3 5 1

R = rref(A\_aug) %Reduced row echelon form of R

R = %Value of R

1.0000 0 0 0.9000 -2.0000 1.3000

0 1.0000 0 2.1600 1.2000 0.5200

0 0 1.0000 -1.0400 2.2000 -0.8800

x1 = R(1:3,6) %Setting x1 to be 6th column of R

x1 = %Value of x1

1.3000

0.5200

-0.8800

x1(4) = 0 %Adding zero to space 4 of vector x1

x1 = %Value of x1

1.3000

0.5200

-0.8800

0

x1(5) = 0 %Adding zero to space 5 of vector x1

x1 = %Value of x1

1.3000

0.5200

-0.8800

0

0

A \* x1 %A times x1

ans = %Value of A times x1

3

5

1

**x1 is a solution to Ax = b since when we multiply A and x1 we get the same value as b**

b %Checking value of b

b = %Value of b

3

5

1

x0 = [R(:,4);-1;0] %Setting value of x0 to be values from 6th space of R and -1 and 0

x0 = %Value of x0

0.9000

2.1600

-1.0400

-1.0000

0

A \* x0 %A times x0

ans = %Value of A times x0

0

0

0

x1 + x0 %x1 plus x0

ans = %Value of x1 plus x0

2.2000

2.6800

-1.9200

-1.0000

0

A \* ans %A times value of x1 plus x0

ans = % Value of A times value of x1 plus x0

3.0000

5.0000

1.0000

x2 = x1 + x0 %Setting x2 to be addition of x1 and x0

x2 = %Value of x2

2.2000

2.6800

-1.9200

-1.0000

0

A \* x2 %A times x2

ans = %Value of A times x2

3.0000

5.0000

1.0000

**x1 plus x0 does give a solution for Ax = b as multiplying A and them gives us the same value as b**

b %Checking value of b

b = %Value of b

3

5

1

ex1 = x1 + 2 \* x0 %Example 1, doing times 2

ex1 = %Value for ex1

3.1000

4.8400

-2.9600

-2.0000

0

A \* ex1 %A times ex1

ans = %Value of A times ex1

3

5

1

b %Checking value of b

b = %Value of b

3

5

1

ex2 = x1 + 3 \* x0 %Example 2, doing times 3

ex2 = %Value for ex2

4

7

-4

-3

0

A \* ex2 %A times ex2

ans = %Value of A times ex2

3

5

1

b %Checking value of b

b = %Value of b

3

5

1

ex3 = x1 + 69 \* x0 %Example 3, doing times 69

ex3 = %Value for ex3

63.4000

149.5600

-72.6400

-69.0000

0

A \* ex3 %A times ex3

ans = %Value of A times ex3

3.0000

5.0000

1.0000

**x1 + a\*x0 works for any a value because when it comes to vectors, you can add them together, you can multiply them by same value, or you can multiply one of them by a value because those are all linear combinations.**

b %Checking value of b

b = %Value of b

3

5

1

Clear %Clear workspace

A = rmat(5,3) %Making a 5x3 random matrix

A = %Value of A

9 9 1

8 7 6

0 3 4

7 0 3

6 3 5

rank(A) %Rank of A

ans = %Value of rank A

3

**For there to be a unique solution for Ax = b, rank A, rank [A b] and the n from the size has to be the same value. So in this case since rank A is 3, rank [A b] and n have to be 3**

b = [19;21;7;10;14] %Make vector with values

b = %Value of b

19

21

7

10

14

A\_aug = [A b] %Putting matrix A and vector b together

A\_aug = %Value of A\_aug

9 9 1 19

8 7 6 21

0 3 4 7

7 0 3 10

6 3 5 14

R = rref(A\_aug) %Reduced row echelon form of A\_aug

R = %Value of R

1 0 0 1

0 1 0 1

0 0 1 1

0 0 0 0

0 0 0 0

x = R(:,4) %Making x equal to 4th column of R

x = %Value of x

1

1

1

0

0

A\b %Checking value of x is right

ans = %Value of A divided by b

1.0000

1.0000

1.0000

x = R(1:3,4) %Setting x to be the first 3 rows of the 4th column

x = %Value of x

1

1

1

A\*x %A times x

ans = %Value of A times x

19

21

7

10

14

b %Checking value of b

b = %Value of b

19

21

7

10

14

diary off %Turning diary off

Unique solutions only occur when rank A, rank [A b] and the n from the size of the matrix are all the same number.

Non-unique solutions occur when the rank A and rank [A b] are the same but less than the value of n from the size of the matrix.

No solutions occur when the rank of A is less than the rank of [A b].