```
format compact
%Raashi Maheshwari
%Last 4 Digits of RUID: 8169
%Section C1
%Math 250 MATLAB Lab Assignment #4
rand('seed', 8169)
A = rmat(3,2)
A =
    9     4
    6     6
    3     7
rank(A)
ans =
    2
%Question 1(a)
u = A(:,1), v = A(:,2)
u =
    9
    6
    3
v =
    4
    6
    7
[s,t] = meshgrid((-1:0.1:1), (-1:0.1:1));
X = s*u(1)+t*v(1); Y = s*u(2)+t*v(2); Z = s*u(3)+t*v(3);
surf(X,Y,Z); axis square; colormap hot, hold on
%Question 1(b)
b = rvect(3)
b =
    3
    8
    4
r = -1:0.05:1;
plot3(r*b(1), r*b(2), r*b(3), '+')
%Since the entire line Span(b) is not in Col(A), we can conclude that b does
%not lie inside Col(A)
%Question 1(c)
%As seen in the graph from the previous part,Since the entire line of Span(b)
%is not in Col(A), there is no vector in R^2 such that Ax = b
%Question 1(d)
z = rand(2,1), c = A*z
z =
   0.7102
   0.6764
c =
   9.0977
   8.3198
   6.8656
```

```
figure, surf(X,Y,Z); axis square; colormap hot, hold on
plot3(r*c(1),r*c(2),r*c(3), '+')
%Question 2
B = rmat(3,3), rank(B)
B =
    5     5     5
    8     9     9
    9     6     8
ans =
    3
A = [B(:,1), B(:,2), 2*B(:,1) + 3*B(:,2), 4*B(:,1) - 5*B(:,2), B(:,3)],
A =
    5     5    25    -5     5
    8     9    43   -13     9
    9     6    36     6     8
R = rref(A)
R =
    1     0     2     4     0
    0     1     3    -5     0
    0     0     0     0     1
%Question 2(a)
%Columns 1, 2, and 5 are pivot columns of A and R because they are linearly
%independent. They do not rely on any other columns and are free variables
%In other words, columns 1, 2, and 5 are not linear combinations of any other
%columns of A and R, hence they are the pivot columns of A and R
%Column #3 and column #4 of R are the corresponding vectors because they are
%linear combinations of other columns.They are linearly dependent columns, and
%rely on the other linearly independent columns
%Question 2(b)
%The free variables are x3 and x4 since those columns (column 3 and 4) are not
%pivot columns
%dimV =  2 since its equal to the nullity(A)
%Question 2(c)
N = nulbasis(A)
N =
   -2    -4
   -3     5
    1     0
    0     1
    0     0
v1 = N(:,1), v2 = N(:,2)
v1 =
   -2
   -3
    1
    0
    0
v2 =
   -4
```

```
     5
     0
     1
     0
%In v1, component 3 is 1 and component 4 and 5 are both 0
%In v2, component 4 is 1 and component 3 and 5 are both 0
A*v1
ans =
     0
     0
     0
A*v2
ans =
     0
     0
     0
%Since both A*v1 and A*v2 return the zero vector as the answer, both v1 and v2
%are in Null(A)
%2(d)
s = rand(1), t = rand(1), x = s*v1 + t*v2
s =
   0.5555
t =
   0.6827
x =
  -3.8418
   1.7472
   0.5555
   0.6827
        0
%x is a linear combination of v1 and v2 from N. Since null space is the span
%found by multiplying the free variables of A, we can say that x satisfies the
%equation Ax = 0.
%Since R is just the reduced row echelon form of A, we can say that x would
%also satisfy the equation Rx = 0
A*x
ans =
  1.0e-14 *
  -0.1776
   0.1776
        0
R*x
ans =
     0
     0
     0
%As shown above, both A*x and R*x are either zero or very close to zero,
%showing that A*x = 0 and R*x = 0
%Question 3
```

```
%Question 3a
A = rmat(5,3), R = rref(A)
A =
    7     1     1
    5     8     1
    1     2     2
    1     8     4
    6     4     9
R =
    1     0     0
    0     1     0
    0     0     1
    0     0     0
    0     0     0
%Since the rank of A is only 3, which is not equivalent to the number of rows
%of A, we can say that the equation Ax = b does not have any solutions in R^5
%and hence Ax = b is not consistent for each b in R^5
%This will occur because when we try to solve the last two rows, it will be
%inconsistent because you will have zero rows set to a non-zero number, which
%will lead it to be inconsistent, and thus will have no solution
b = rmat(5,1), xp = partic(A, b)
b =
    9
    2
    9
    5
    8
xp =
    []
b = rand(1)*A(:,1) + rand(1)*A(:,2) + rand(1)*A(:,3)
b =
   6.7415
  11.4879
   3.4819
   9.7860
  12.3332
xp = partic(A,b)
xp =
   0.7693
   0.8979
   0.4584
A*xp
ans =
   6.7415
  11.4879
   3.4819
   9.7860
  12.3332
%As seen above, A*xp is equal to b
```

```
%Since the vector b is a linear combination of the columns of A, we can say
%that the matrix equation Ax = b is consistent and has a solution
%Question 3(b)
A = rmat(3,5), R = rref(A)
A =
    7     7     2     2     6
    1     2     7     8     8
    0     4     6     1     3
R =
   1.0000         0         0    1.7740    1.5959
        0    1.0000         0   -1.8973   -1.0890
        0         0    1.0000    1.4315    1.2260
%Since the rank of the matrix is equivalent to the number of rows it has (3 ==
%3), we can say that the equation Ax = b has at least one solution for each b
%in R^m. This means that Ax = b is consistent.
%Along with that, we see that there are two free variables, which shows that
%there is an infinite number of solutions
b = rmat(3,1), xp = partic(A, b)
b =
    4
    5
    0
xp =
   1.6027
  -1.2740
   0.8493
        0
        0
%the entries in row 4 and 5 of xp are zero because in Matrix R, which is the
%rref version of matrix A, we know that x4 and x5 are free variables
A*xp
ans =
   4.0000
   5.0000
        0
%As we can see above, A*xp is equal to b
%Question 4
A = [7 7 2 2 6; 1 2 7 8 8; 0 4 6 1 3]
A =
    7     7     2     2     6
    1     2     7     8     8
    0     4     6     1     3
b = [4; 5; 0]
b =
    4
    5
    0
%Question 4(a)
N = nulbasis(A)
```

```
N =
  -1.7740   -1.5959
   1.8973    1.0890
  -1.4315   -1.2260
   1.0000         0
        0    1.0000
v1 = N(:,1), v2 = N(:,2)
v1 =
  -1.7740
   1.8973
  -1.4315
   1.0000
        0
v2 =
  -1.5959
   1.0890
  -1.2260
        0
   1.0000
x = xp + rand(1)*v1 + rand(1)*v2
x =
  -0.4861
   0.6120
  -0.8015
   0.6706
   0.5635
A*x
ans =
   4.0000
   5.0000
        0
%As seen above, A*x is equal to the vector b
%Question 4(b)
X = xp - 9*v1 + 8*v2
X =
   4.8014
  -9.6370
   3.9247
  -9.0000
   8.0000
A*X
ans =
   4.0000
   5.0000
   0.0000
%As seen above, A*x is the vector b
%Question 5
A = [0.30 0; 0.14 0; 0.56 1]
A =
```

```
   0.3000         0
   0.1400         0
   0.5600    1.0000
B = [0.5 0 0; 0.5 1 0.6; 0 0 0.4]
B =
   0.5000         0         0
   0.5000    1.0000    0.6000
        0         0    0.4000
C = [1 0.3 0; 0 0.2 0; 0 0.35 0.7; 0 0.15 0.3]
C =
   1.0000    0.3000         0
        0    0.2000         0
        0    0.3500    0.7000
        0    0.1500    0.3000
M = C*B*A
M =
   0.3378    0.1800
   0.1252    0.1200
   0.3759    0.4900
   0.1611    0.2100
%Question 5(a)
x = 1000*rvect(2), y = A*x, z = B*y, w = C*z
x =
       4000
       4000
y =
       1200
        560
       6240
z =
        600
       4904
       2496
w =
  1.0e+03 *
   2.0712
   0.9808
   3.4636
   1.4844
[1 1]*x, [1 1 1]*y, [1 1 1]*z, [1 1 1 1]*w
ans =
       8000
ans =
       8000
ans =
       8000
ans =
       8000
```

```
%The above four numbers represent the total number of cars entering/exiting
%the respective lanes
%The first number([1 1]*x) represents the number of cars that pass through x1
%and x2 towards the 1 way streets
%The second and third number ([1 1 1]*y and [1 1 1]*z) represents the numbers
%of cars that pass through the intersections of y and z, respectively
%The last number ([1 1 1 1]*w) represents the number of cars that are exiting
%The numbers will be the same because they represent the total number of cars
%that are in the system and on the roads
%Question 5(b)
y = [270 126 704]
y =
  270   126   704
%Since there are three equations but only two vectors for x, the equation Ax =
%b will not have a solution for all of the vectors (y)
%Question 5(c)
w = [100 200 300 400]
w =
  100   200   300   400
rref([M w])
ans =
     1     0     0
     0     1     0
     0     0     1
     0     0     0
%As seen above, since the matrix [M w] is not consistent with w = M*x, we can
%conclude that there is no value such that W can be an output traffic vector
```