CDS130 Final exam   (PART I)

The final exam consists of two sections. The first section is a closed–book paper exam (60 minutes); and the second section involves use of Matlab on the computer (75 minutes). The following part is the first section of the exam.

• Be sure your exam booklet has 10 pages for this section.
• Write your name at the top of each page.
• This is a closed book exam.
• All computational commands and statements appearing in this exam are specifically referring to the Matlab programming language taught in class.
• You may not use Matlab on the computer during this section.
• Absolutely no interaction between students is allowed.
• Each question is worth 5 points. Partial credit may be awarded ONLY if work is shown.
• Duration for this section: 60 minutes (10:30am − 11:30am).

Q1. Colors can be specified by RGB triples in Matlab. For example, the red, greed, blue colors can be represented by

Red = [1, 0, 0];
Green = [0,1,0];
Blue = [0, 0, 1];

NewColor = (Red*0.5) | (Green*0.5) & (~Blue)

What is the color of the combination of the Red, Green, Blue colors specified above? i.e., what is the color of NewColor?

(A) Black
(B) Red
(C) Green
(D) Blue
(E) None of the above

Answer: ___B___

Based on the matlab code given, we first work out the values in NewColor, which is NewColor

        = ([1,0,0]*0.5) | ([0,0,1]*0.5 & (~[0,0,1])

Following the operation precedence (~, (), mathematical operations, relational operations, &, |), we have

NewColor

        = [0.5,0,0) | [0,0,0.5] & [1,1,0]

 NewColor

        = [0.5,0,0] | [0,0,0]

NewColor = [1,0,0], which corresponds to the Red color.

The correct answer is B

Q2. A matrix was generated using

M = rand(10);

Which of the following statements are valid in Matlab?
(A) M+M*2
(B) M(1, :)^2
(C) exp(M)
(D) M(10,10)+M(3,6)
(E) M > 0.5 + ~ M
(F) M(2:4, 5:6)

Answer_____

Solution:

rand(10) generates a 10x10 matrix with (10 row, 10 columns).

(A) valid.

(B) This is incorrect. The exponentiation operation is not valid in this case. It makes sense if it is written: M(1, :) .^2

(C) valid.

(D) valid

(E) valid

(F) valid

The correct answer:

(A), (C), (D) (E), (F)

Q3. What is the output of executing the following Matlab code?
```
clear;
for i=1:3
   for j=i:3
    M(i, j) = i+j;
    M (j, i) = j-i;
   end
end
M
```

Solution: this is the same problem that appeared in your second quiz.
The double nested for loops generate a 3x3 matrix. During each iteration a new matrix element will be generated.

Iteration 1: i=1, j=1,
            M(1,1) = 2
            M(1,1) = 0
(note here, the new value for M(1,1) is 0, not 2).

Iteration 2: i=1, j=2,
            M(1,2) = 3
            M(2,1) = 1

Iteration 3: i=1, j=3,
            M(1,3) = 4

            M(3,1) = 2

Iteration 4: i=2, j=2
            M(2,2) = 4
            M(2,2) = 0
Iteration 5 i=2, j=3
            M(2,3) = 5
            M(3,2) = 1

iteration 6 i=3, j=3
            M(3,3) = 6
            M(3,3) = 0

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The correct answer is:

```
0  3  4
1  0  5
2  1  0
```

Q4. Using one if-statement to rewrite the following nested if-statement

if w < x
  if w > y
     w = x*y
  end
end

Answer:

if w<x & w > y

   W= x*y

end

Q5. Using nested for-loops to generate a matrix that has elements shown below (without typing the numbers explicitly):

$$A = \begin{pmatrix} 1 & 12 & 123 & 1234 \\ 2 & 23 & 234 & 2345 \\ 3 & 34 & 345 & 3456 \\ 4 & 45 & 456 & 4567 \end{pmatrix}$$

Answer:

Solution 1:

```
clear all; clc;
for i=1:4
     A(i, 1) = i;
     for j = 2:4
            A(i,j) = A(i,j-1) *10 + i+j-1;
     end
end
A
```

Solution 2:

```
clear all; clc;
for i=1:4
     counter = i;
     A(i,1) = i;
     for j = 2:4
            A(i,j) = counter*10 + counter +1;
     end
end
A
```

Q6. Given three random numbers a, b, c, write a short Matlab code in the box to detect the maximum value and assign the value to the variable MAX.

```
clear; clc;
a=rand(1);
b=rand(1);
c=rand(1);

if (a > b & a > c)
  MAX = a;
elseif (b > a & b > c)
  MAX = b;
else
  MAX = c;
end
```

disp(' The maximum value is')
MAX

Q7. Images in Matlab are represented by matrices. In order to properly display the image with desired colors, a color map is needed (for indexed images). Given a matrix

$$M = \begin{pmatrix} 0.1 & 0.5 & 0.7 \\ 0.9 & 0.4 & 0.6 \\ 0.5 & 0.8 & 0.2 \end{pmatrix}$$

with the following Matlab code:

M=[0.1, 0.5, 0.7; 0.9, 0.4, 0.6; 0.5, 0.8, 0.2];
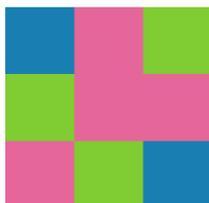colormap(M);
imagesc(~(M>0.5))
axis square off

Which of the following statements is most likely correct?
(A) No image will be produced, because the colormap is not properly assigned.

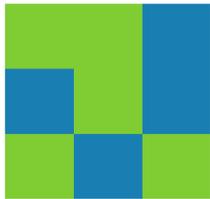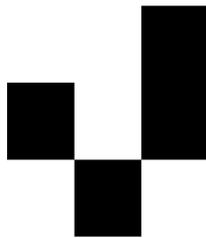(B) The following image will be produced:

(C) The following 3-color image will be produced:

(D)The following 2-color image will be produced:

(E) The following white and black image will be produced:

Answer: _____

Soluiton:

The key is to find the content of the image matrix in the command
imagesc(~(M>0.5))

recall: M
= [0.1, 0.5, 0.7; 0.9, 0.4, 0.6; 0.5, 0.8, 0.2];

therefore, (M>0.5) has the following content:
[0, 0,1; 0.5, 0, 1, 0, 1, 0]
~(M>0.5) becomes
[1, 1, 0; 0, 1, 0; 1, 0 1]

From this image matrix, one can tell,
(1) there are only two colors in the picture
(2) the 1's have the same color (the colors are giving by the colormap defined by M).

Based on these two observations, one can tell
(D) is the correct answer.

8. Given the following Matlab code,

```
k= 0;
while  2 * k ^0.5 < k +1
     k = k + 1;
end
k
```

what is the value of k after executing the code?

Solution:

First, plug k=0 into the condition 2 * k ^0.5 < k +1, because this is a true statement, the block in the while will be executed, which means
$$k = 0 +1$$
k now becomes 1.

Since this is a while loop, which means as long as the condition is true, the iteration will go on.

On the second step, plug k = 1 into the condition 2 * k ^0.5 < k +1, which corresponds to the condition 2 < 2. This is a false statement. The while loop is now halted (i.e., the block in the while loop will not be executed).

The answer is

1

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Q9. Write a Matlab code to find the largest integer i to satisfy the following inequality:

$$3*(2+1)+4*(3+2+1)+5*(4+3+2+1)+6*(5+4+...+1)+i*[(i-1)+(i-2)+...+1]<100000$$

Solution:

we need a for-loop to calculate the sum of each term on the left side .

clear all; clc;

sum = 0
i =3;

while sum < 100000
   result = 0;
   for j = i-1:-1:1
      result = result + j;
   end
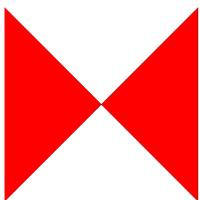
   sum = sum + i*result;
   i=i+1;
end

i

10. The 'fill' command can be used to plot polygons with filled colors. Which plot will be generated by executing the following command lines?

clear;
fill([0, 1, 1, 0], [1,1, 0, 0], [0,0,1]);
axis square off;

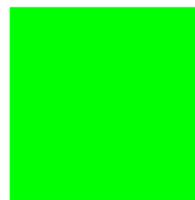(A)   (B)   (C)   (D)   (E)

None of the above

Answer:
the color [0,0,1] is blue.
The correct answer is: C

Sample: CDS130 Final exam   (PART II)

The final exam consists of two sections. The first section is a closed-book paper exam (60 minutes); and the second section involves use of Matlab on the computer (75 minutes). The following part is the second section of the exam.

• Make sure you have 4 pages for this section.
• You are required to use Matlab to solve the problems.
• Absolutely no interaction between students is allowed.
• Partial credit may be awarded ONLY if work is shown.
• Turn in your Matlab code and final answers by email (hsheng@gmu.edu)
• Duration for this section: 75 minutes (8:30am − 9:45am).

Q1. (10 points) Write a Matlab script to create an image as follows: (Note: you need to provide seven colors and the correct orientation of the strips.)
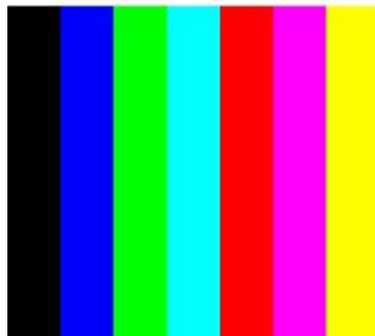
Answer:

Solution 1:

```
clear all; clc;
map = [0,0,0; 0,0,1; 0,1,0; 1,1,0; 1,0,0; 1,0,1; 0,1,1];

for i=1:7
   for j=1:7
      A(i,j) = j;
   end
end

 colormap(map);
 image(A)
axis off
```

Solution 2:

```
clear all; clc;
map = [0,0,0; 0,0,1; 0,1,0; 1,1,0; 1,0,0; 1,0,1; 0,1,1];
a = [0 0 1 1];
b = [0 7 7 0];
hold on
for i=1:7
 fill (a+i, b, map(i,:))
end

axis off
```

Q2. (10 points) There are many formulae for computing π , for example

$$\frac{\pi}{8} = \frac{1}{1 \times 3} + \frac{1}{5 \times 7} + \frac{1}{9 \times 11} + \ldots$$

(1) write a Matlab script to compute π using the provided formulae .

(2) and determine how many terms in the series are needed to reach 3.1415 for π

Answer:
**(1) Suppose we need 100 terms to calulate π**

```
clear all; clc;
nterms = 100;
sum = 0;
for i=1:nterms
 a = 1 + 4*(i-1);
 b = a +2;
 sum = sum + 1 / (a*b);
end
sum = sum*8
disp('PI is approximately');
sum*8
```

(2) We compare the "sum" derived from the first problem with the value of pi (3.1415926..). If the value is less than pi, we need more terms to increase the accuracy. Let's start from 10 terms. (my final answer to this problem is: 4871 terms).

```
clear all; clc;
nterms =10;
sum = 0;
while (abs(sum - 3.1415) > 0.00001)
  nterms = nterms +1;
  sum = 0;
  for i=1:nterms
    a = 1 + 4*(i-1);
    b = a +2;
    sum = sum + 1 / (a*b);
  end
  sum = sum*8;
end
```

3. (15 points) Given two mathematical functions $f(x)=\dfrac{1}{x}\exp\left[-(\ln(x)-1)^2\right]$,

$g(x)=\sin^2(x)-0.5$ calculate the area between the two curves from x=1.5 to x = 6.5 as shown in the following figure.
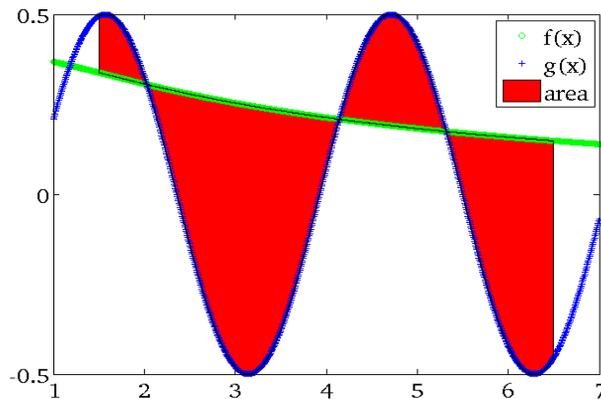
clear all; clc;

xL = 1.5;
xR = 6.5;
n = 1000;
dx = (xR-xL)/n
area = 0;
for x = xL:dx:xR-dx
    f1 = exp((log(x)-1)^2)/x;
    g1 = (sin(x))^2 - 0.5;
     x = x + dx;
    f2 = exp((log(x)-1)^2)/x;
    g2 = (sin(x))^2 - 0.5;

    f = (f1+f2)*dx/2;
     g = (g1+g2)*dx/2;
    area = area + abs (f-g);
end

area

Q4 (15 points) Consider the following model of population

Every year, population increases a value of 10% of the population in the previous year. However, if the predicted population is over 100, a disease outbreak instantly kills 60% of this predicted population value. For example, if the predicted population is 110, then the next year the population is 0.4*110.

Use Matlab to plot population as a function of time for 50 years. Assume that the initial population is 25.

Solution:

clear all; clc;

p(1) = 25;

birthRate = 0.1;
deathRate = 0.6;

for i=2:50
     p(i) = p(i-1) + p(i-1)*birthRate ;

     if (p(i) > 100)
        p(i) = p(i) - p(i) *deathRate;

     end
end
p(50)

        68.3