Matrices, Cont'd

Storing two-dimensional numerical data

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Analyzing table data

level	1998	1999	2000	2001	2002	2003	2004	2005
advanced	7	9	15	18	20	24	29	35
proficient	17	15	18	27	24	27	28	27
needs improvement	24	23	22	30	31	29	28	24
failing	52	53	45	25	25	20	15	15

Statewide results for MCAS Test in Mathematics, Grade 10

Indexing with colon notation

To refer to an *entire column* of a matrix, provide **:** as the first index and the column number as the second index

```
>> nums(:, 3)
ans =
     3
     8
    13
    18
```

nums

$$\begin{array}{c|ccccc} & 1 & 2 & 3 & 4 & 5 \\ \hline 1 & 1 & 2 & 3 & 4 & 5 \\ 2 & 6 & 7 & 8 & 9 & 10 \\ 3 & 11 & 12 & 13 & 14 & 15 \\ 4 & 16 & 17 & 18 & 19 & 20 \end{array}$$

To refer to an *entire row* of a matrix, provide **:** as the second index and the row number as the first index

```
>> nums(2, :)
   ans =
        6   7    8    9   10
```

Plotting trends in performance levels

We begin our analysis by plotting the data for each performance level over the 8 years

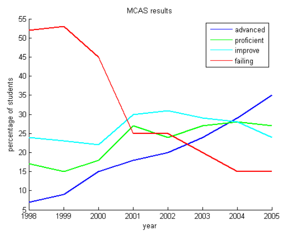
```
% create matrices that store data and years
results =  [ 7    9  15  18  20  24  29  35; ...
            17  15  18  27  24  27  28  27; ...
            24  23  22  30  31  29  28  24; ...
            52  53  45  25  25  20  15  15];

years = [1998 1999 2000 2001 2002 2003 2004 2005];
```

Each row of the table corresponds to a performance level. How do we plot the resulting trend over the given years?

Plotting the data

```
% plot the data for each performance level vs. years
hold on
plot(years, results(1,:), 'b', 'LineWidth', 2);
plot(years, results(2,:), 'g', 'LineWidth', 2);
plot(years, results(3,:), 'c', 'LineWidth', 2);
plot(years, results(4,:), 'r', 'LineWidth', 2);
hold off
```



```
xlabel('year')
ylabel('percentage of students')
title('MCAS results')
legend('advanced', 'proficient', 'improve', 'failing' );
```

Finally, ...

Suppose we want to print the *change in results* between 1998 and 2005 for each performance level…

How do we do this?

```
Change in performance between 1998 and 2005:
advanced: 28%
proficient: 10%
needs improvement: 0%
failing: -37%
```

Printing changes in results

```
% print total change in results between 1998 and 2005

totalChange = results(:, end) - results(:, 1);

disp('Change in performance between 1998 and 2005:');
disp(['advanced: ' num2str(totalChange(1)) '%']);
disp(['proficient: ' num2str(totalChange(2)) '%']);
disp(['needs improvement: ' num2str(totalChange(3)) '%']);
disp(['failing: ' num2str(totalChange(4)) '%']);
```

```
Change in performance between 1998 and 2005:
advanced: 28%
proficient: 10%
needs improvement: 0%
failing: -37%
```

Time-out exercise

For each year, compute a *weighted sum* of the four percentages, using a weight of 1 for “advanced”, 2 for “proficient”, 3 for “needs improvement” and 4 for “failing”*

```
overallPerformance =
```

Add a new row to the **results** matrix that stores these weighted sums

* The resulting sum can range from 100 (great!) to 400 (not so good…)

More indexing with colon notation

We can use colon notation to refer to a *range of indices* within a column or row of a matrix

```
>> nums(1:3, 4)
ans =
      4
      9
     14
>> nums(3, 3:5)
ans =
     13  14  15
>> nums(2:3, 2:4)
ans =
      7   8   9
     12  13  14
```

nums	1	2	3	4	5
1	1	2	3	4	5
2	6	7	8	9	10
3	11	12	13	14	15
4	16	17	18	19	20

Conditional operations on matrices

A conditional expression can be *applied to an entire matrix all at once* producing a new matrix of the same size that contains logical values

```
ages = [13  52  19  21;  18  47  23  15;  60  38  16  12];
teens = (ages >= 13) & (ages <= 19);
```

ages

13	52	19	21
18	47	23	15
60	38	16	12

teens

1	0	1	0
1	0	0	1
0	0	1	0

Using logical vectors

```
>> ages(teens) = 0
ages =
    0   52    0   21
    0   47   23    0
   60   38    0   12

>> overTheHill = ages(ages>40)
overTheHill =
   60
   52
   47
```

ages

13	52	19	21
18	47	23	15
60	38	16	12

teens

1	0	1	0
1	0	0	1
0	0	1	0

Tip on min & max

```
>> nums1 = [4  1  7];
>> [minVal minInd] = min(nums1)
minVal =
    1
minInd =
    2
>> [maxVal maxInd] = max(nums1)
maxVal =
    7
maxInd =
    3
```

What if there's more than one occurrence of the min or max value??

```
>> nums1 = [4  1  7  1];
>> [minVal minInd] = min(nums1)
minVal =
    1
minInd =
    2
```

How could you create a *logical vector* that's true wherever the min value appears?

Time-out exercise

Given:

- matrix `medals` with three rows that store number of gold, silver & bronze medals won by countries in the 2018 Winter Olympics
- cell array of corresponding country names
- vector of populations for each country

```
medals = [9   0   6   13   4   1   12; ...
          5   5   5   11   3   0   7; ...
          7   2   6   9   2   3   5];

names = {'Canada' 'China' 'US' 'Norway' 'South Korea' ...
        'Great Britain' 'Germany'}

pops = [36624200  1409517400  324459500  5233000  ...
        50982200  65640000  82114200];
```

Write code to do the following:

(1) create a vector with the total medals for each country

(2) print the name of the country with the most total medals

(3) print the name of the country with the largest per capita total medals

(4) print the names of countries with more bronze medals than gold and silver medals combined

(5) print the names of countries with the least number of bronze medals