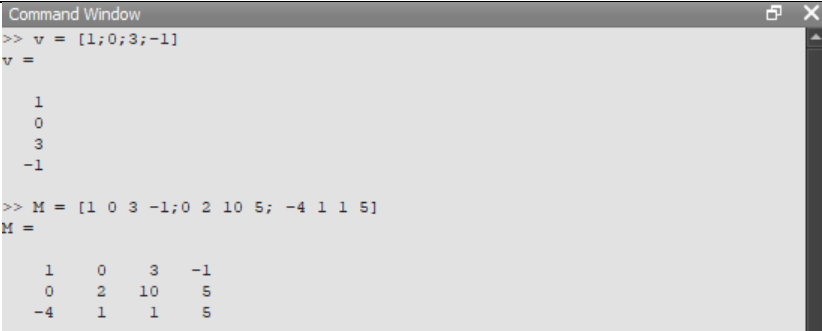
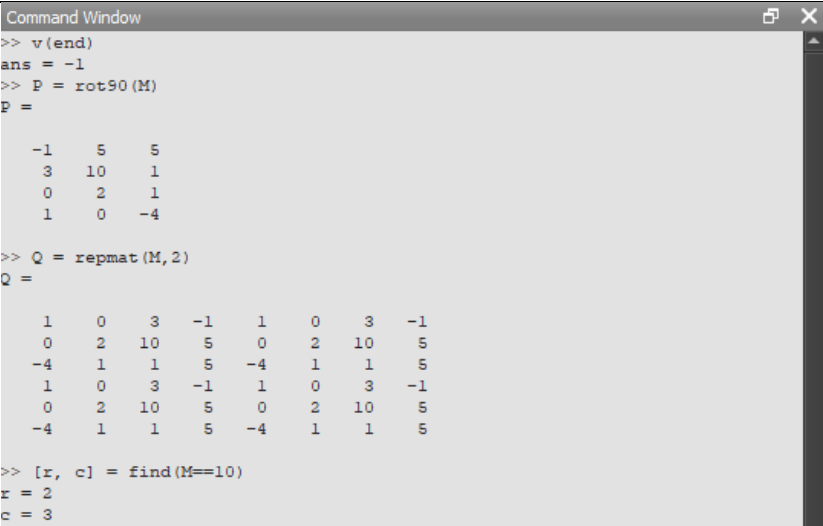
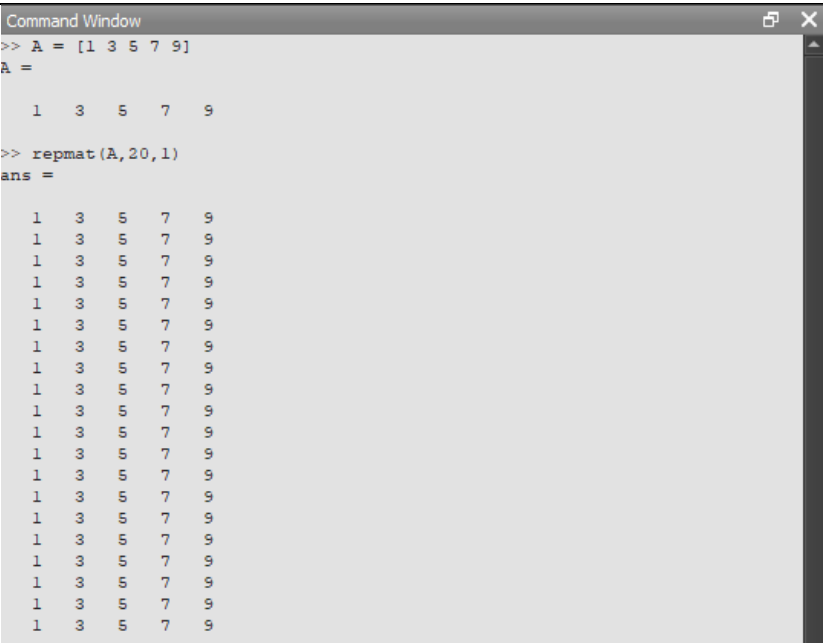
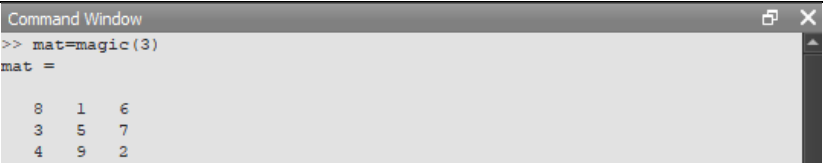
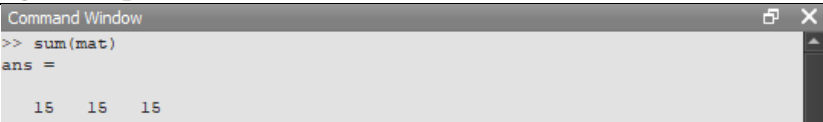
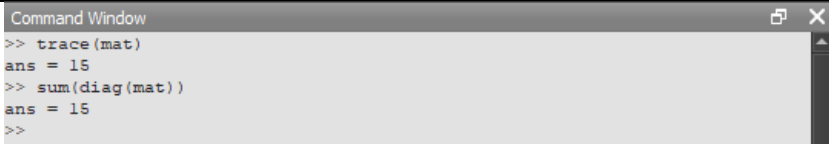
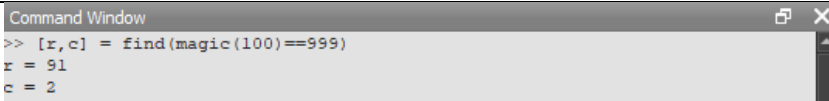
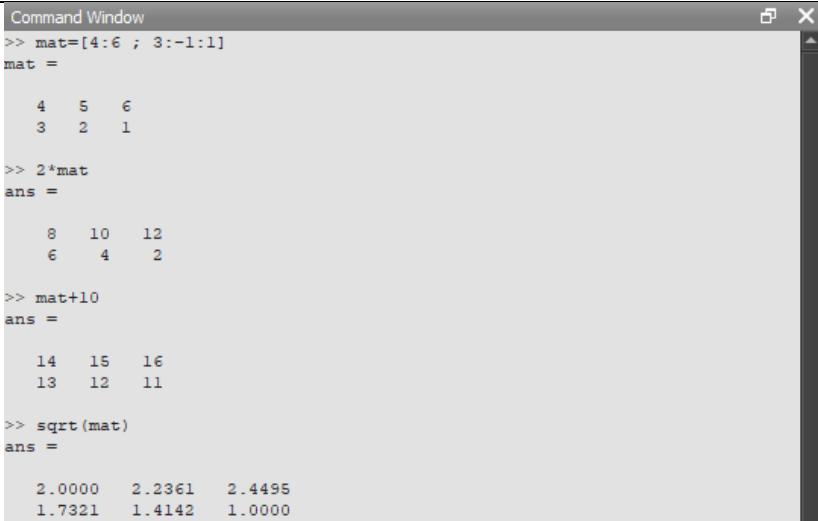
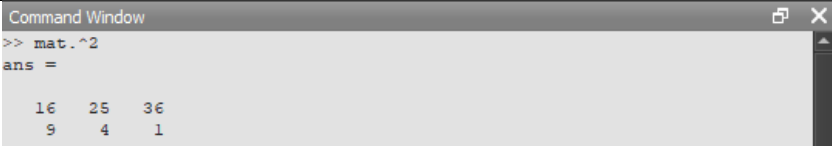
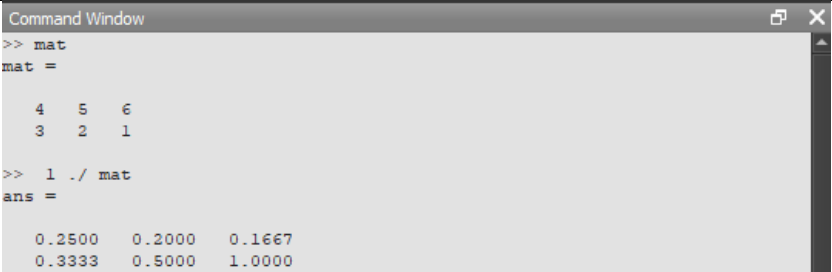


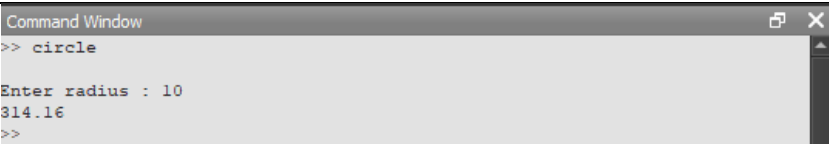

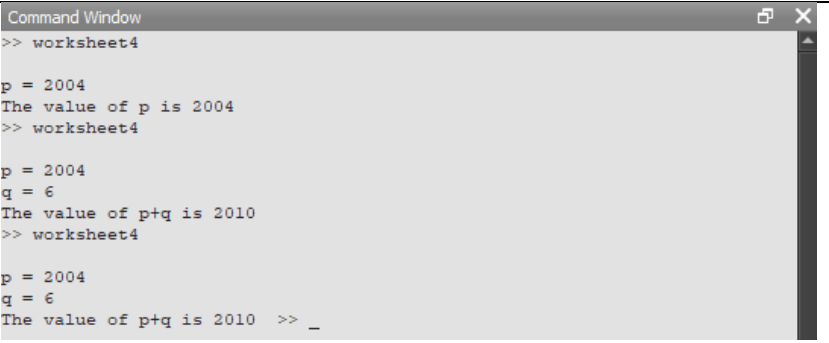


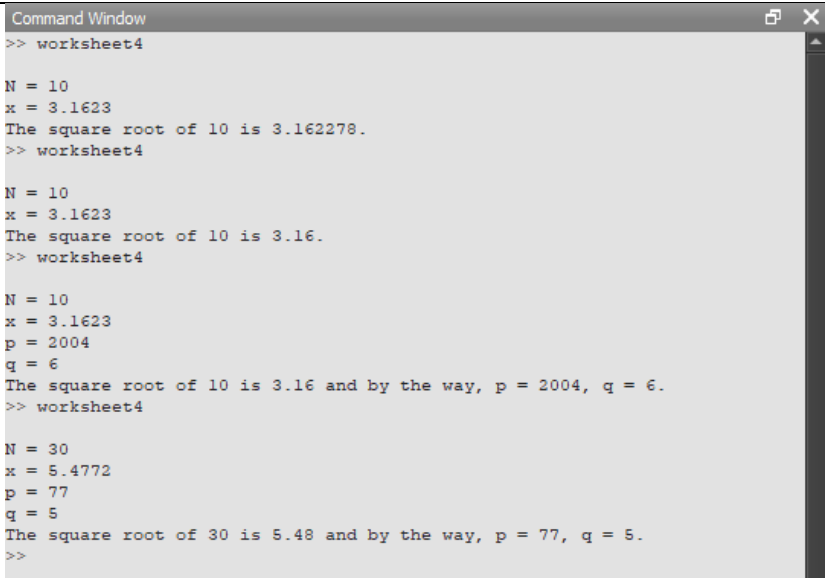
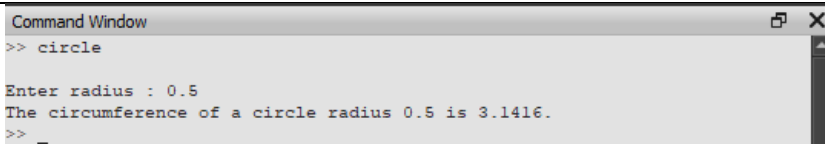
Material	Quest	Worksheet																						
Matrix Operations	Q1	1. All about arrays. Let's use MATLAB to play with vectors and matrices (all considered <i>arrays</i> in MATLAB). In your command window, create the following row vector v and matrix M (see Sheet 2 if you've forgotten how).																						
	Answer																							
	Q2	<table><tr><th>Command</th><th>effect on a vector</th><th>effect on a matrix</th></tr><tr><td>size</td><td>gives the dimension of the vector in the form [#rows, #columns].</td><td>gives the dimension of the matrix in the form [#rows, #columns].</td></tr><tr><td>length</td><td></td><td></td></tr><tr><td>numel</td><td></td><td></td></tr><tr><td>max</td><td></td><td></td></tr><tr><td>sum</td><td></td><td></td></tr><tr><td>prod</td><td></td><td></td></tr></table>		Command	effect on a vector	effect on a matrix	size	gives the dimension of the vector in the form [#rows, #columns].	gives the dimension of the matrix in the form [#rows, #columns].	length			numel			max			sum			prod		
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Q3	i) Devise a command which picks out the <i>overall maximum</i> of M (i.e. 10 in this case).																							
Answer	Command : max(max(m))																							
Q4	<table><tr><td>v(end)</td><td></td></tr><tr><td>P = rot90(M)</td><td></td></tr><tr><td>Q = repmat(M,2)</td><td></td></tr><tr><td>[r,c] = find(M==10)</td><td></td></tr></table>		v(end)		P = rot90(M)		Q = repmat(M,2)		[r,c] = find(M==10)															
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	Answer	 <pre> Command Window >> v(end) ans = -1 >> P = rot90(M) P = -1 5 5 3 10 1 0 2 1 1 0 -4 >> Q = repmat(M,2) Q = 1 0 3 -1 1 0 3 -1 0 2 10 5 0 2 10 5 -4 1 1 5 -4 1 1 5 1 0 3 -1 1 0 3 -1 0 2 10 5 0 2 10 5 -4 1 1 5 -4 1 1 5 >> [r, c] = find(M==10) r = 2 c = 3 </pre>
	Q5	<p>iii) Write down a line of command which will quickly generate a matrix <i>A</i> which consists of 20 rows of the array (1 3 5 7 9).</p>
	Answer	 <pre> Command Window >> A = [1 3 5 7 9] A = 1 3 5 7 9 >> repmat(A,20,1) ans = 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 1 3 5 7 9 </pre>
	Q6	<p>2. <u>Magic squares</u>. Generate a 3×3 matrix called <i>mat</i>, with the command</p> <pre>mat=magic(3)</pre>
	Answer	 <pre> Command Window >> mat=magic(3) mat = 8 1 6 3 5 7 4 9 2 </pre>
	Q7	<p>i) What commands can be used to verify that the rows and columns of <i>mat</i> all add up to the magic total?</p>
	Answer	 <pre> Command Window >> sum(mat) ans = 15 15 15 </pre>

	Q8	<p>ii) The <i>trace</i> of a matrix is defined as the sum of the entries along its main diagonal (i.e. top left to bottom right).</p> <p>Write down two lines of commands which can be used to verify that the 2 diagonals of <code>mat</code> add up to the magic total?</p>
	Answer	
	Q9	<p>iii) Calculate the magic total for a 51×51 magic square.</p> <p>Command: _____ Numerical answer: _____</p>
	Answer	Command : magic(51) Numerical answer : 66351
	Q10	<p>iv) In which row/column does the entry 999 appear in the 100×100 magic square? Give the command used (avoid any low-tech method).</p>
	Answer	
	Q11	<p>3. <u>Element-wise operations</u>. We will often need to perform operations on entire arrays of numbers, element by element.</p> <p>For example, let's start with the matrix <code>mat=[4:6 ; 3:-1:1]</code> (see last week's sheet if this command doesn't make sense).</p> <p>a) To multiply every element of <code>mat</code> by 2, we type _____. Easy enough. Similar for division. Describe what the following commands do.</p> <p style="text-align: center;"><code>mat+10</code> <code>sqrt(mat)</code></p>
	Answer	
	Q12	<p>b) Using ideas from last week, or otherwise, write down <u>two</u> ways in which you can quickly create a 15×20 matrix consisting entirely of numbers 9.</p>
	Answer	A = 9 * ones(15,20) A = repmat(9,15,20,1)
	Q13	<p>c) Now let's suppose we want to square every element in the matrix, so that the desired result is</p> $\begin{pmatrix} 16 & 25 & 36 \\ 9 & 4 & 1 \end{pmatrix}$

		<p>The command <code>mat^2</code> will produce an error because, as you may know, a 2-by-3 matrix cannot be multiplied to another 2-by-3 matrix.</p> <p>Instead, to perform an <i>element-wise</i> operation, simply place <code>a dot</code> in front of the operation. In this case, the command</p> $\text{mat}.^2$
	Answer	 <pre> Command Window >> mat.^2 ans = 16 25 36 9 4 1 </pre>
	Q14	i) What command can be used to produce a matrix consisting of the reciprocals of the elements of <code>mat</code> ?
	Answer	 <pre> Command Window >> mat mat = 4 5 6 3 2 1 >> 1 ./ mat ans = 0.2500 0.2000 0.1667 0.3333 0.5000 1.0000 </pre>
	Q15	<p>ii) In fact, we can use the <code>.*</code> operation to multiply (or <code>./</code> to divide) two matrices element-wise. For instance, you can check that</p> $\text{mat}.*\text{mat}$ <p>gives exactly the same result as <code>mat.^2</code>. Now fill in the blanks below.</p> $\text{mat}.*\begin{pmatrix} 0 & -1 & -2 \\ 1 & 0.5 & 10 \end{pmatrix} = \begin{pmatrix} & & \\ & & \end{pmatrix}$ $\text{mat}.*\begin{pmatrix} & & \\ & & \end{pmatrix} = \begin{pmatrix} 7 & 8 & 9 \\ 9 & 8 & 7 \end{pmatrix}$ <p>Warning: Always use <code>/</code> and <code>./</code> for division. There is also the backslash <code>\</code>, but you will only need it in when solving linear systems. Don't confuse the two slashes.</p>
	Answer	 <pre> Command Window >> mat.*[0 -1 -2; 1 0.5 10] ans = 0 -5 -12 3 1 10 >> mat./[7 8 9; 9 8 7] ans = 0.5714 0.6250 0.6667 0.3333 0.2500 0.1429 </pre>
Input-Output	Q1	<p>1. <u>Hello world</u>. The first step is to create a MATLAB script by clicking <i>New >> Script</i>. The “Hello world” script has been a traditional rite of passage for all beginning programmers since the early 70s, and here it is in MATLAB version. In the Editor window (not the Command Window), type</p> $\text{disp('Hello world')}$ <p>Now go back to the Command Window, and type <code>hello</code>. MATLAB should respond with <i>Hello world</i>.</p>

	Answer	 <pre> Command Window >> hello Hello World >> </pre>
	Q2	<p>In <code>circle.m</code>, type the four lines in the box below.</p> <pre> 1 % This script calculates the area of a circle of a given radius 2 r = input('Enter radius : '); 3 area = pi*r^2; 4 disp(area) </pre>
	Answer	 <pre> Command Window >> circle Enter radius : 10 314.16 >> </pre>
	Q3	<p><input type="checkbox"/> Modify <code>circle.m</code> so that it now calculates and displays the <i>circumference</i> of a circle of a given radius.</p> <p><input type="checkbox"/> Run your scripts to find the circumference of a circle with the following radii: a) 0.5 b) $\sqrt{2}$ (Ans: a) 3.1416, b) 8.8858)</p>
	Answer	 <pre> Command Window >> circle Enter radius : 0.5 3.1416 >> circle Enter radius : sqrt(2) 8.8858 >> </pre>
	Q4	<p><input type="checkbox"/> Redefine <code>p</code> to be any integer you like, and run the same <code>fprintf</code> command above again. Do you see your new value of <code>p</code> displayed?</p> <p><input type="checkbox"/> Define another variable <code>q = 6</code> and use <code>fprintf</code> to display</p> <p style="text-align: center;">The value of <code>p+q</code> is ♥</p> <p>where ♥ is some integer which MATLAB should automatically calculate. Change the value of <code>q</code> and check that MATLAB still displays the correct value of <code>p+q</code>.</p> <p><input type="checkbox"/> Delete <code>\n</code> and run the same <code>fprintf</code> command again. Do you see what <code>\n</code> does? Forgetting to use <code>\n</code> will leave the user with an annoyingly messy screen, especially when several <code>fprintf</code> commands are used.</p>
	Answer	 <pre> Command Window >> worksheet4 p = 2004 The value of p is 2004 >> worksheet4 p = 2004 q = 6 The value of p+q is 2010 >> worksheet4 p = 2004 q = 6 The value of p+q is 2010 >> _ </pre>

	Q5	<p>Let's define <code>N=10</code> and <code>x=sqrt(N)</code>. To display The square root of 10 is 3.162278.</p> <p>Use the command</p> <pre>fprintf('The square root of %d is %f. \n', N, x)</pre> <p>Now consult the Table and modify the above <code>fprintf</code> command to produce each of these two lines.</p> <p><input type="checkbox"/> The square root of 10 is 3.16.</p> <p><input type="checkbox"/> The square root of 10 is 3.16 and by the way, <code>p=♡</code>, <code>q=♡</code>. [where the ♡ are your previously defined values of <code>p</code> and <code>q</code>.]</p> <p><input type="checkbox"/> Redefine variables <code>p</code>, <code>q</code>, <code>N</code> to be whatever new integers you like. Define <code>x=sqrt(N)</code> again, and rerun the last <code>fprintf</code> command. Did MATLAB display the updated values of all your variables?</p>
	Answer	 <pre>Command Window >> worksheet4 N = 10 x = 3.1623 The square root of 10 is 3.162278. >> worksheet4 N = 10 x = 3.1623 The square root of 10 is 3.16. >> worksheet4 N = 10 x = 3.1623 p = 2004 q = 6 The square root of 10 is 3.16 and by the way, p = 2004, q = 6. >> worksheet4 N = 30 x = 5.4772 p = 77 q = 5 The square root of 30 is 5.48 and by the way, p = 77, q = 5. >></pre>
	Q6	<p><input type="checkbox"/> Go back to your <code>circle.m</code> and “comment out” the last line (by putting % in front of <code>disp</code>). Insert a new display command using <code>fprintf</code> instead (with appropriate conversion characters).</p> <p>If done correctly, your code should be able to display something like:</p> <p>The circumference of a circle radius 0.5 is 3.1416</p>
	Answer	 <pre>Command Window >> circle Enter radius : 0.5 The circumference of a circle radius 0.5 is 3.1416. >> _</pre>