ENHANCED STUDENT LEARNING WITH WEEKLY MATLAB LABS

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Lab and Class Detail

- Weekly laboratory on Fridays.
- Class meetings:
  - Three 50 minute periods, 2 in a traditional classroom, *lab day* in a computer classroom with MATLAB access.
- Course Book:
  - *Elementary Linear Algebra*, Anton, Rorres , 11th (Wiley)
- Labs:
  - *MATLAB Linear Algebra Manual and Lab Projects*, at the Companion Site for Elementary Linear Algebra 11th edition by Anton/Rorres.

Some Observations

- Positives:
  - Student comprehension of topics has improved
  - Students, after the first couple of labs, work together in teams and help each other learn. They ask few questions in lab on lab days
  - Student attention seems better, retention is up
- Shortcomings:
  - Some students miss labs that never miss class in the standard classroom. May be due in part to a.) labs being mostly self contained, b.) lab day on Friday
  - Increase in material to grade

Pre-Course Student Feedback

- Reason for taking class:
  - Required/Elective, 43 (Math, CS, Engineering); Wish to learn MATLAB, 3; Heard it is fun, 1
- Assessment of impact of Labs in learning:
  - *Should help*, 19; *Could help*, 16; *Not sure*, 8; *None*, 2.
- Some statements on value of Labs to learning
  - *Principles(10)*: "Help me get a concrete understanding of principles."
  - *Visualization(5)*: "Gets a visual experience going."
  - *Applications(8)*: "In previous math classes labs focused on applications, which really helped."
  - *Hands On Experiences(7)*: "It is hands on work."
  - *Not sure(2)*: "labs never helped me before."
  - *Not sure(4)*: "Never had a math class with a lab."

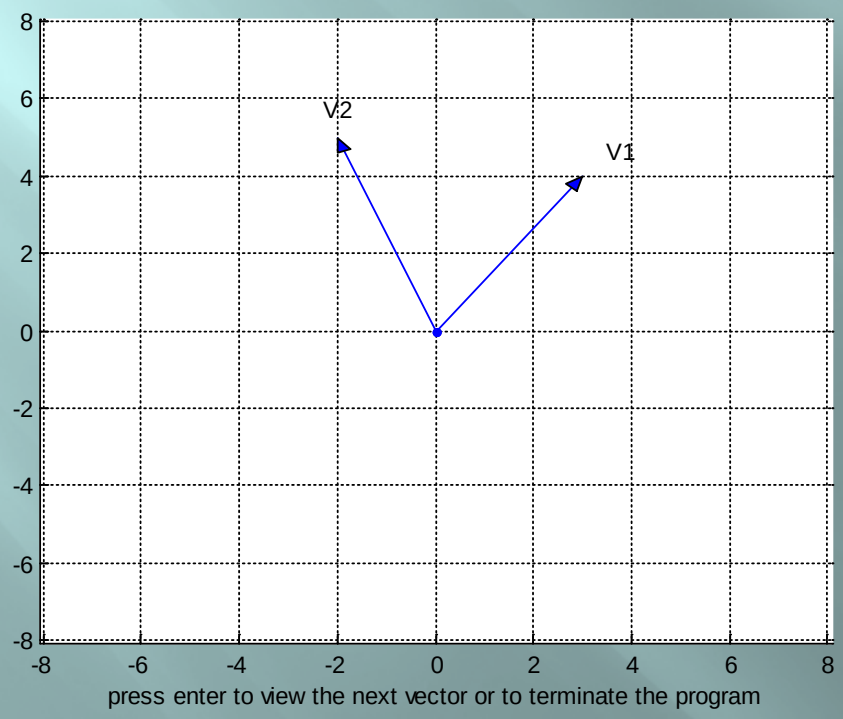
Labs Assigned Fall 2014

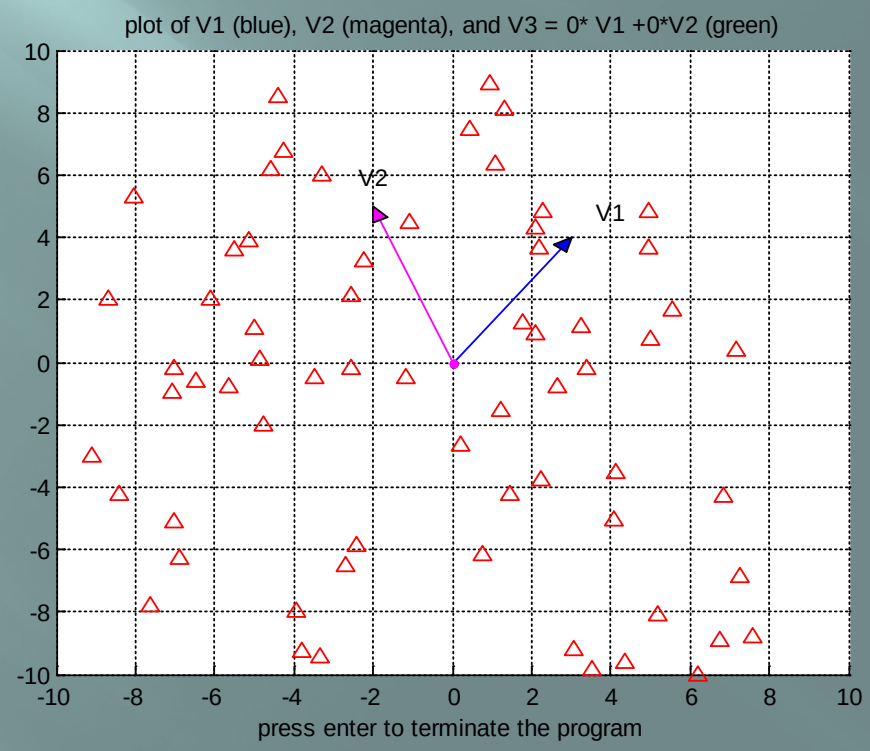
- *Lab 1* - Introduction to MATLAB
- *Lab 2* - Solving Systems of Linear Equations in Matrix Form with *rref*
- *Lab 6* - Solving Systems of Linear Equations with the Inverse Matrix
- *Lab 4* - Linear Algebra and Chemistry: Combustion In Excess Oxygen
- *Lab 7* – Determinants
- *Lab 3* - Linear Combinations and Span
- *Lab 12* – Norms, Inner Product and Projections
- *Lab 16* – Linear Transformations
- *Lab 5* - Rank and Linear
- *Lab 9* – Basis
- *Lab 10* – Eigenvalues and Eigenvectors
- *Lab 13* – Gram-Schmidt and QR Decomposition
- *Lab 11* – Linear Algebra and Systems of Differential Equations

Samples from Labs: *Linear Combinations and Span*

11. View 5, 50, 100, and 200 random linear combinations of $u = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$ and $v = \begin{bmatrix} -2 \\ 5 \end{bmatrix}$ with the m-file *viewlincomb*. Discuss your observations. Based on the plot of the multiple random linear combinations of u and v, what conclusion can you draw about $Span\{u, v\}$?

- With 100 linear combinations:

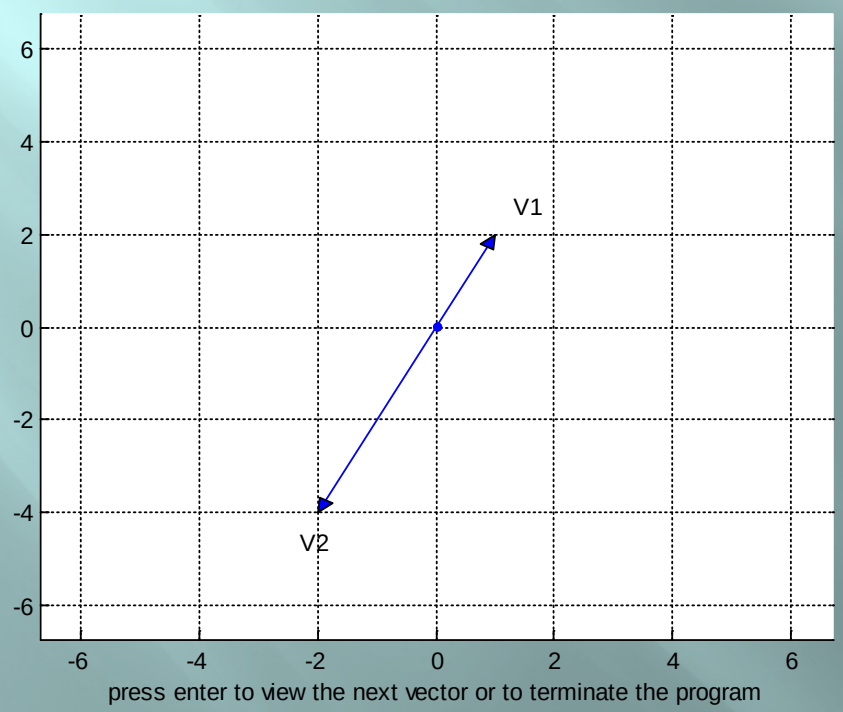


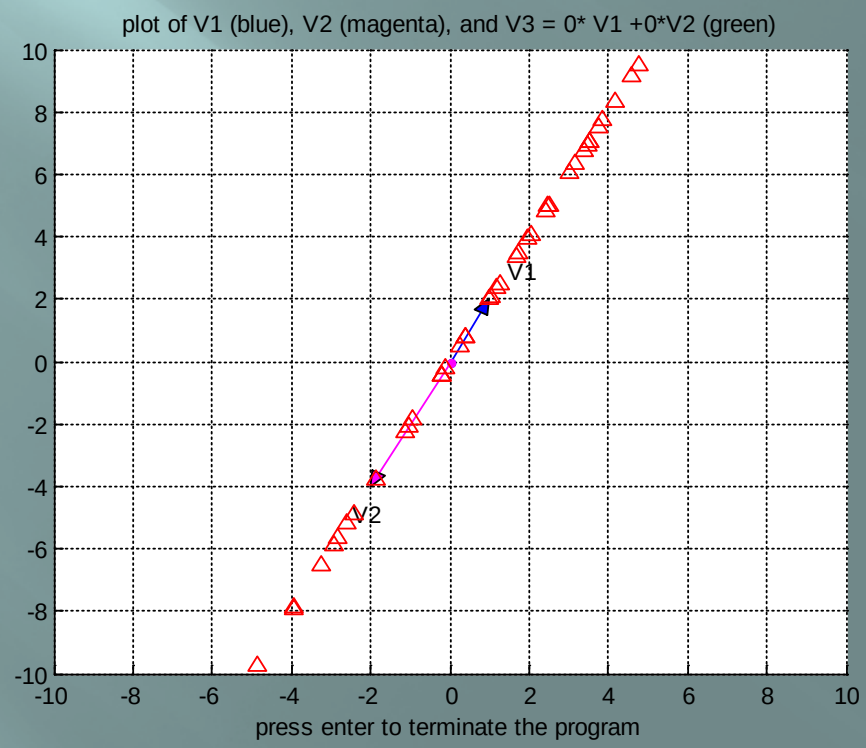


Linear Combinations and Span

13. View 5, 50, 100, and 200 random linear combinations of $u = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ and $v = \begin{bmatrix} -2 \\ -4 \end{bmatrix}$ with the m-file *viewlincomb*. Discuss your observations. Based on the plot of the multiple random linear combinations of u and v, what conclusion can you draw about $Span\{u, v\}$?

- With 50 linear combinations:





Samples from Labs: Determinants

III. Build a 5 X 5 random matrix, A : A = randi (10,5).

a.) Compute the determinant of ; det(A) = _____

b.) Set row 2 of A to 10 times the values in row 2, A(2,:) = 10* A(2,:). det(A) = ?

a= randi (10,5)

10	1	7	2	2
9	8	7	3	10
4	6	9	9	8
7	5	9	1	6
2	10	6	5	5

det(a) = 16277

a(2,:) = 10* a(2,:)

10	1	7	2	2
90	80	70	30	100
4	6	9	9	8
7	5	9	1	6
2	10	6	5	5

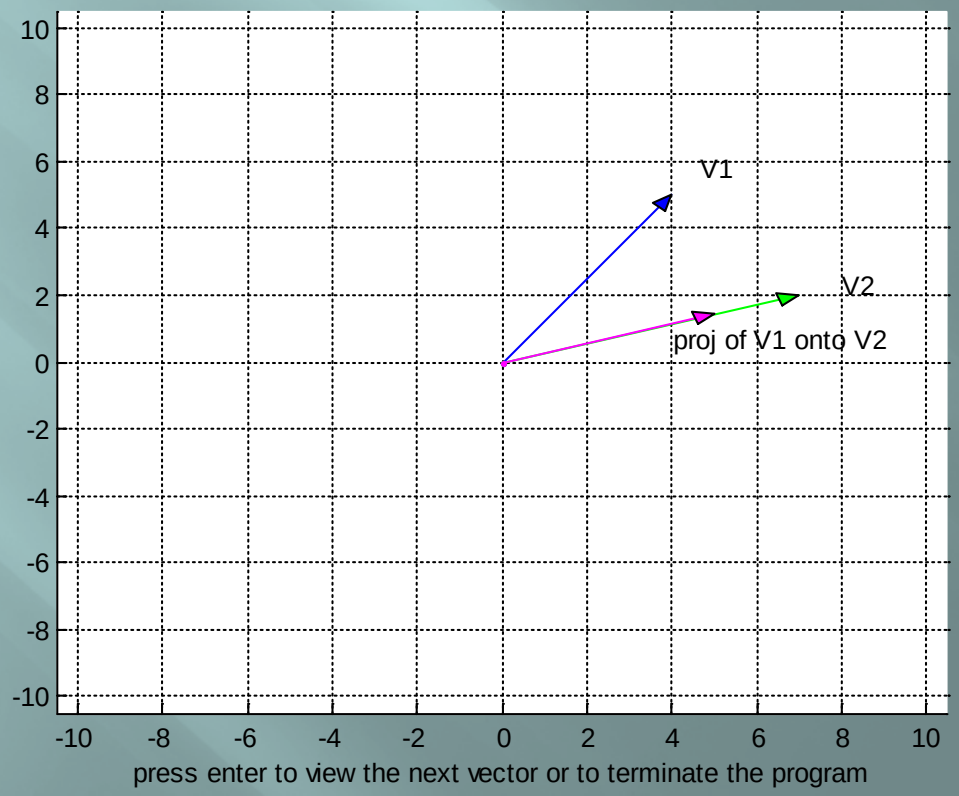
det(a) = 162770

Conjecture: $|G| = ____ |A|$

Samples from Labs:
Norms, Inner Products and Projections

Example 3: For vectors *u* and *v* of example 2, determine the projection of *u* onto *v* then apply the m-file *viewprojection* to view the *u*, *v*, and the projection.

```
projuonv = dot(u,v)/(norm(v)*norm(v))*v
   5.0189
   1.4340
viewprojection(u,v)
```



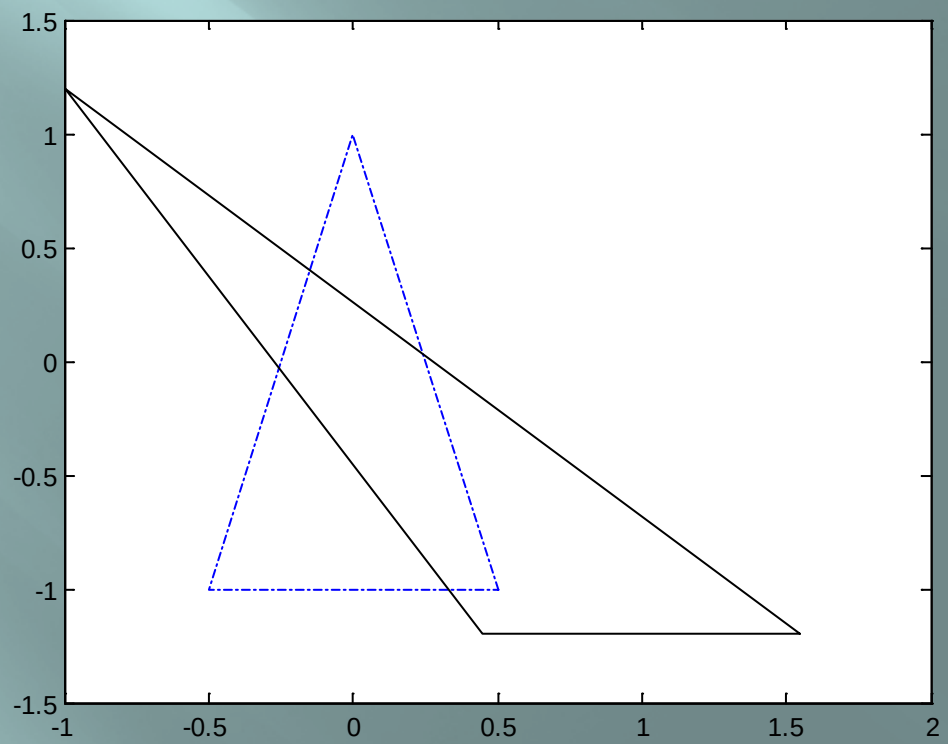
Samples from Labs: Matrix Transformations

Example 2: Let the transition matrix be

$$T = \begin{bmatrix} 1.1 & -1 \\ 0 & 1.2 \end{bmatrix}$$

Apply the transformation operator to the triangle and view the action, transformation produced,

```
x=[0.5  0  -0.5  0.5]; y=[-1  1  -1  -1]; P=[x;y]
T=[1.1 -1;0 1.2];
P2=T*P
clf
plot(P(1,:),P(2,:),'-.',P2(1,:),P2(2,:),'k');shg
hold on
P2=T*P2;  plot(P2(1,:),P2(2,:),'k');shg
```



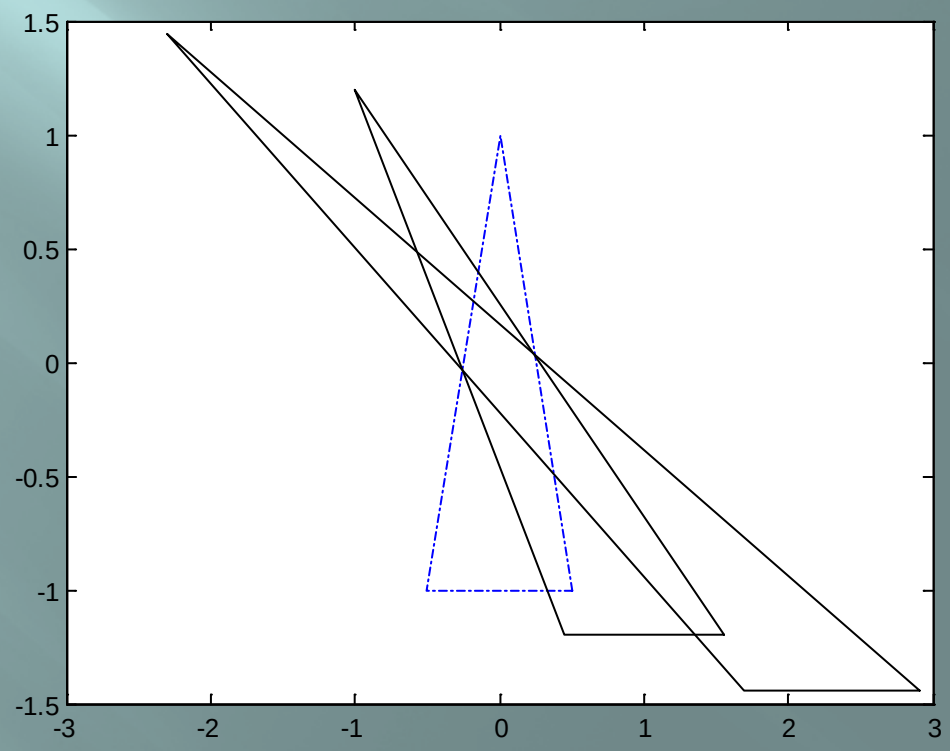
Samples from Labs: Matrix Transformations

Apply the operator 1 more time and view the transformations of the triangle due to the action of the operator together.

hold on

P2=T*P2; plot(P2(1,:),P2(2,:),'k');shg

$$T = \begin{bmatrix} 1.1 & -1 \\ 0 & 1.2 \end{bmatrix}$$



Post-Course Student Feedback

- *Rate the impact of the Labs to help you:*

	Not Much Difference	Not Sure	Some Difference	Total Difference Maker
Grasp Concepts and Theories	2	5	17	13
Grasp Use and Applications	1	3	20	13

- *Rate the Impact of Technology to Enhance:*

	Not Much Difference	Not Sure	Some Difference	Total Difference Maker
Understanding of Concepts	2	2	21	12

Post-Course Student Feedback

- *Identify any concept(s) that the use of labs and explorations has helped you understand better*
  - **Eigenvalues (6)** : *"Was crucial in my learning and understanding eigenvalues"*
  - **Chemistry (4)** : *"… I was so excited. … I found a faster and efficient way but also understand how balancing worked."*
  - **Transformations (5)** : *"I found it interesting how an image could be transformed with a single matrix equation."*
  - **Span and Linear Independence (4)** : *"Span was a good way to understand linear independence"; "I liked the lab on linear independence. Working through those labs allowed me to learn and discover many concepts on my own."*
  - **Determinants (5)** : *"This topic was a bit shaky prior to the lab. But after working on the lab with my group it was much more clear."*

Post-Course Student Feedback

- *Identify any concept(s) that the use of labs and explorations has helped you understand better*
  - **RREF (6)** : *"It helped me understand the purpose of rref."*
  - **Projections and norms (2)** : *"Projection because it helped see it better."*
  - *Others:* **Basis (1)**, **DE (2)**, **Grahm-Schmidt (2)**, **Intro to Matlab (1)**
- *Identify a concept of linear algebra that the labs did not help clarify:*
  - **None, all helped (8)**
  - *Subspaces (2), Eigenvalues (4), Basis (1), Span (1), Unit Balls (1), Real World Use (1), RREF (2), Transformations (1)*

Future and References

- Some tasks:
  - Add minor subtopics, maybe sort out how help get a handle on subspaces
  - Compile and summarize assessment and feedback data
  - Find more cool applications for some Labs
- References associated with the Labs and other Lab materials
  - *Elementary Linear Algebra,* 11th edition by Anton/Rorres (Wiley)
  - Labs (2014) at www.wiley.com/college/anton the Companion Site, Elementary Linear Algebra, 11th, Anton/Rorres
  - *ATLAST Computer Exercises for Linear Algebra*, S. Leon, E. Herman, and R. Faulkenberry, Prentice Hall (2002)
  - *Linear Algebra Labs with MATLAB*, 3rd Ed., D. Hill and D. Zitarelli, Prentice Hall (2003)

THANK YOU FOR YOUR ATTENTION!

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