Jeff Anderson’s

Applied Linear Algebra Playlists

Below is a list of YouTube playlists that I created as supplementary materials for my Math 2B course. You can find these, and many other additional resources, that I provide to my students on our course homepage:

<http://www.appliedlinearalgebra.com/blog/for-students/welcome-to-math-2b>

I provide links to both the playlists and the individual videos found within. I also show the length of each video.

Finally, the column labeled “Complete” is a great place to track your progress through these videos. I recommend that you track the amount of time you spend watching each video in that column. If you are taking notes and struggling in productive ways to understand the concepts in each video, I bet that you’ll spend more time than the length of each video (my bet is that the ratio is somewhere between 2 and 4: you’ll spend 2X – 4X the amount of time watching each video than the length of the video itself).

The best way to figure out how long it takes you to watch this content is to track your work. If you get in this habit early in the class, you’ll collect a lot of data to help guide your guesses about how long it takes you to watch these videos and take notes on the content. One of the most difficult aspects of learning in college is [accurately predicting how much time it takes to learn](https://thelearningcode.school.blog/2020/11/20/schedule-to-succeed-plan-to-fudge-it-up/) material. By systematically tracking your progress, you’ll build insights into that larger question.

MATH 2B, Lesson 0

[Fundamental Problems of Applied Linear Algebra](https://www.youtube.com/playlist?list=PLSt7rwoPGTy10qdPeuqzC-qn5zeHCYoSf) (8 Videos: 1h, 20m, 23s)

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| Video Title | Length | Complete |
| 1. [What is the Applied Math Modeling Problem](https://www.youtube.com/watch?v=pnOSCKAd2qQ) | 16m, 38s |  |
| 2. [Three Pillars of Applied Math](https://www.youtube.com/watch?v=kMYENO06oTM) | 4m, 33s |  |
| 3. [What is the Matrix-Vector Multiplication Problem](https://www.youtube.com/watch?v=Cv0vt0Jc7tw)  | 7m, 03s |  |
| 4. [What is the Nonsingular Linear-Systems Problem](https://www.youtube.com/watch?v=3aDZP0e93Jw) | 5m, 46s |  |
| 5. [What are the three most fundamental problems in linear algebra?](https://www.youtube.com/watch?v=tDBf4bVwNwE)  | 18m, 23s |  |
| 6. [What is the General Linear-Systems Problem?](What%20is%20the%20General%20Linear-Systems%20Problem%3F) | 3m, 19s |  |
| 7. [What quadratic equations teach us about general linear systems?](https://www.youtube.com/watch?v=Y214YfPcnRM) | 11m, 07s |  |
| 8. [What are the three types of solutions to genera linear systems?](https://www.youtube.com/watch?v=sOECRF2FnIs) | 13m, 34s |  |

MATH 2B, Lesson 1

[Introduction to Set Theory](https://www.youtube.com/playlist?list=PLSt7rwoPGTy2QZJtnhppR7K5SrF0kBezX) (12 Videos: 1h, 04m, 54s)

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| Video Title | Length | Complete |
| 1. [Introduction to Set Theory](https://youtu.be/RqafvWmeA7A) | 4m, 8s |  |
| 2. [Definition of Set](https://youtu.be/r2lgx3JvWnk) | 3m, 13s |  |
| 3. [Define Sets via Enumeration](https://youtu.be/emyd7R4dX50) | 4m, 46s |  |
| 4. [Element Inclusion and Truth Values](https://youtu.be/D4xOHqovqho) | 6m, 59s |  |
| 5. [Example 3 Stanley’s Brace Notation](https://youtu.be/l6EjeBmgnrs) | 3m, 9s |  |
| 6. [Set Builder Notation](https://youtu.be/ThNjfU3M5fM) | 3m, 19s |  |
| 7. [Example of Set Builder Notation](https://youtu.be/Uhlo6cVfpQQ) | 3m, 28s |  |
| 8. [Definition of Famous Number Systems](https://youtu.be/tv6E-vALTuU) | 7m, 27s |  |
| 9. [Definition of Subsets](https://youtu.be/FAh_jWXJT2o) | 7m, 27s |  |
| 10. [Subset Proof](https://youtu.be/602247Sm__Q)  | 6m,41s |  |
| 11. [Definition of Set Equality](https://youtu.be/YKFscwP8GS0) | 4m, 54s |  |
| 12. [Example of Proving Set Equality](https://youtu.be/vH3OzqC6TNs) | 7m, 45s |  |

MATH 2B, Lesson 2

[Relations and Functions](https://www.youtube.com/playlist?list=PLSt7rwoPGTy3ZlyL4KYhWOjULDTh1b-Xu) (10 Videos: 54m, 30s)

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| Video Title | Length | Complete |
| 1. [Why do we care about codomain in Linear Algebra](https://www.youtube.com/watch?v=WLo4lAUmEdI)  | 14m, 07s |  |
| 2. [Definition of cross product of sets](https://youtu.be/aqta1OpSz7Y) | 2m, 28s |  |
| 3. [Example of cross product of sets for voting map](https://youtu.be/kIizgi7n2Gw) | 2m, 29s |  |
| 4. [Example of cross product of sets for lexagraphical ordering](https://youtu.be/vnBSav6ycYA) | 1m, 49 |  |
| 5. [Set theory definition of relation between sets](https://youtu.be/F-7NaRVqlrY) | 5m, 12s |  |
| 6. [Dial pad relation](https://youtu.be/lyl84Zrj0R4) | 5m, 36s |  |
| 7. [Definition of domain and range](https://youtu.be/YeU7HoWwk-c) | 7m, 56s |  |
| 8. [Example of domain and range for dial pad relation](https://youtu.be/7qjYbTtxkt4) | 2m, 58s |  |
| 9. [Example of domain and range for ellipse relation](https://youtu.be/79YCv2Wt1R0) | 3m, 29s |  |
| 10. [Set theoretic definition of a function](https://youtu.be/o51V_lKIHsU) | 8m, 30s |  |

MATH 2B, Lesson 3

[Vector Modeling](https://www.youtube.com/playlist?list=PLSt7rwoPGTy2K4w5Nz6aMYWUU5b3nJsGP) (6 Videos: 57m, 38s)

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| Video Title | Length | Complete |
| 1. [Introduction to and definition of a column vector](https://youtu.be/nT8qhKZWKa4) | 6m, 36s |  |
| 2. [Hooke’s law experiment set up](https://youtu.be/93yBnXKjFyk) | 10m, 21s |  |
| 3. [Hooke’s law experiment data set](https://youtu.be/Zs6cKPZRfag) | 5m, 8s |  |
| 4. [Example of vector model for grades in math class](https://youtu.be/5eXQj_J4Uak) | 6m, 46s |  |
| 5. [Example of 2-mass, 3-spring chain set up](https://youtu.be/kPIrUaEhUng) | 22m, 50s |  |
| 6. [Mathematize the 2-mass, 3-spring chain](https://youtu.be/Ri94Dt-SW9M) | 5m, 57s |  |

MATH 2B, Lesson 4

[Vector Arithmetic](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq) (10 Videos: 1h, 23m, 25s)

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| Video Title | Length | Complete |
| 1. [Introduction to vector arithmetic](https://www.youtube.com/watch?v=MtdQFNxX5PA&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=1) | 1m, 22s |  |
| 2. [Definition of scalar-vector multiplication](https://www.youtube.com/watch?v=W89c8OdgtuE&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=2) | 5m, 43s |  |
| 3. [Example of Hooke’s law experiment spring forces](https://www.youtube.com/watch?v=BTKrQwqfN04&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=3) | 6m, 4s |  |
| 4. [Geometric interpretation of scalar-vector multiplication](https://www.youtube.com/watch?v=5JsfmSpuZEs&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=4) | 9m, 35s |  |
| 5. [Definition of column vector addition](https://www.youtube.com/watch?v=v8v4iLGHNJk&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=5) | 6m, 56s |  |
| 6. [Example of the geometry of vector addition](https://www.youtube.com/watch?v=V0YOLs_T2Uw&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=6) | 12m, 4s |  |
| 7. [Example of vector arithmetic in mass-spring chain](https://www.youtube.com/watch?v=Bys67LdD-T8&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=7) | 8m, 17s |  |
| 8. [Example of vector arithmetic in Hooke’s law](https://www.youtube.com/watch?v=_n1N9jMcc1M&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=8) | 12m, 43s |  |
| 9. [Algebraic properties of vector arithmetic](https://www.youtube.com/watch?v=E3DlNBzvVi8&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=9) | 14m, 5s |  |
| 10. [Vector transpose with algebraic properties](https://www.youtube.com/watch?v=X6aJ0SCAogo&list=PLSt7rwoPGTy0oUcSSTIXmnO_T3NM6euAq&index=10) | 6m, 36s |  |

MATH 2B, Lesson 5

[Inner Products and Vector Norms](https://www.youtube.com/playlist?list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C) (16 videos: 2h, 23m, 44s)

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| Video Title | Length | Complete |
| 1. [Definition of inner product between column vectors](https://www.youtube.com/watch?v=mb1xg-9BVCc&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=1) | 3m, 13s |  |
| 2. [Example of inner product to calculate grades](https://www.youtube.com/watch?v=XNEjZGFGvqQ&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=2) | 1m, 40s |  |
| 3. [Algebraic properties of the inner product](https://www.youtube.com/watch?v=6A8G31PrNlk&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=3)  | 3m, 52s |  |
| 4. [Proof of linearity in left argument of inner product in $R^{n}$](https://www.youtube.com/watch?v=ZtXwi5AGsXg&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=4)  | 5m, 21s |  |
| 5. [Definition of 2-norm in $R^{n}$](https://www.youtube.com/watch?v=11asSbcmcoo&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=5) | 8m, 46s |  |
| 6. [Algebraic properties of the 2-norm in $R^{n}$](https://www.youtube.com/watch?v=dwWmxqeNk7k&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=6) | 2m, 45s |  |
| 7. [Proof of positivity of the 2-norm in $R^{n}$](https://www.youtube.com/watch?v=uptPhq7f65s&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=7) | 5m, 16s |  |
| 8. [Proof of homogeneity of the 2-norm in $R^{n}$](https://www.youtube.com/watch?v=RdfNnSksa3Y&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=8) | 12m, 0s |  |
| 9. [Pre-requisite review for cosine formula of inner product](https://www.youtube.com/watch?v=cBWvn3t8RfA&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=9) | 7m, 40s |  |
| 10. [Proof of Pythagorean theorem](https://www.youtube.com/watch?v=w07dnAQ45bU&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=10)  | 8m, 54s |  |
| 11. [Proof of acute case of law of cosines](https://www.youtube.com/watch?v=mYUqGwwB4PY&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=11) | 9m, 59s |  |
| 12. [Proof of obtuse case of law of cosines](https://www.youtube.com/watch?v=t9EEUfyjCB0&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=12) | 14m, 54s |  |
| 13. [Proof of cosine formula for inner product](https://www.youtube.com/watch?v=og-W3Fga0Rw&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=13) | 22m, 6s |  |
| 14. [Geometric intuition from cosine formula for inner product](https://www.youtube.com/watch?v=gF3VnYZE6DQ&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=14) | 10m, 32s |  |
| 15. [Direction versus orientation of a vector](https://www.youtube.com/watch?v=eChHzrQWENk&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=15)  | 13m, 18s |  |
| 16. [Proof of triangle inequality for the 2-norm in $R^{n}$](https://www.youtube.com/watch?v=tNF83h0CrAs&list=PLSt7rwoPGTy2xGLHTVppxPkrRfRp1m87C&index=16) | 13m, 28s |  |

Lesson 6

[Span and Linear Independence](https://www.youtube.com/playlist?list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk) (20 Videos: 1h, 59m, 00s)

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| Video Title | Length | Complete |
| 1. [Definition of linear combinations in $R^{n}$](https://www.youtube.com/watch?v=29hGQwBEQ2g&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=1) | 9m, 06s |  |
| 2. [More about linearity](https://www.youtube.com/watch?v=tm9MEchi2dY&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=2) | 3m, 21s |  |
| 3. [Example 1 of linear combinations](https://www.youtube.com/watch?v=jSRIzQDAT64&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=3) | 8m, 46s |  |
| 4. [Example 2 of linear combinations](https://www.youtube.com/watch?v=aPaehVc-FvI&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=4)  | 15m, 34s |  |
| 5. [Example 3 of linear combinations](https://www.youtube.com/watch?v=CeXAcVUNdz0&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=5) | 7m, 02s |  |
| 6. [Example 4 of linear combinations](https://www.youtube.com/watch?v=kEHcQjnu51c&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=6) | 5m, 46s |  |
| 7. [Definition of span in $R^{n}$](https://www.youtube.com/watch?v=ZWeLFA9OGbU&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=7) | 5m, 20s |  |
| 8. [Example 1 of span of vectors](https://www.youtube.com/watch?v=IxMLqumi5ts&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=8) | 2m, 27s |  |
| 9. [Example 2 of span of vectors](https://www.youtube.com/watch?v=6rsqYu2uQtU&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=9) | 9m, 08s |  |
| 10. [Definition 1 of linear dependence in $R^{n}$](https://www.youtube.com/watch?v=m0ga_tmL74I&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=10) | 4m, 2s |  |
| 11. [Definition 2 of linear dependence in $R^{n}$](https://www.youtube.com/watch?v=JZiYDAONQfM&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=11) | 4m, 53s |  |
| 12. [Example 1 of linear dependence](https://www.youtube.com/watch?v=QmjCA2mvDg8&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=12) | 6m, 29s |  |
| 13. [Example 2 of linear dependence](https://www.youtube.com/watch?v=n_yRv0OGY4o&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=13) | 8m, 38s |  |
| 14. [Definition of linearly dependent set of vectors in $R^{n}$](https://www.youtube.com/watch?v=poPJnftC5yY&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=14) | 5m, 19s |  |
| 15. [Example 1 of linearly dependent set](https://www.youtube.com/watch?v=QBIEXUU9Of8&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=15) | 2m, 26s |  |
| 16. [Test for linear dependence in $R^{n}$](https://www.youtube.com/watch?v=xeUk1IPGKwE&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=16) | 6m, 15s |  |
| 17. [Example 1 of test for linear dependence](https://www.youtube.com/watch?v=9u3uQ_yCio4&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=17)  | 4m, 24s |  |
| 18. [Example 2 of test for linear dependence](https://www.youtube.com/watch?v=OV70NY0-tkU&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=18) | 3m, 44s |  |
| 19. [Definition of linear independence](https://www.youtube.com/watch?v=Jwko3IB2m8w&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=19) | 3m, 16s |  |
| 20. [Example 1 of linear independence](https://www.youtube.com/watch?v=dJuLFTjh1fU&list=PLSt7rwoPGTy094Yu_fFUkGEjuGDMoCKTk&index=20) | 3m, 04s |  |

MATH 2B, Lesson 7

[Matrix Modeling](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH) (9 videos: 1h, 41m, 01s)

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| Video Title | Length | Complete |
| 1. [Concept diagram for linear algebraic operations](https://www.youtube.com/watch?v=2Byxj0_tI6g&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=1) | 15m, 17s |  |
| 2. [Entry-by-entry definition of a matrix](https://www.youtube.com/watch?v=DaoLnzMg9XM&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=2) | 6m, 25s |  |
| 3. [What’s in an entry?](https://www.youtube.com/watch?v=6z6zVVntoH8&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=3)  | 2m, 08s |  |
| 4. [Wireframe model in 2D](https://www.youtube.com/watch?v=vN2AhZF0reA&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=4) | 7m 41s |  |
| 5. [Wireframe model in 3D](https://www.youtube.com/watch?v=FDDl5PQBAkM&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=5) | 8m, 46s |  |
| 6. [Polygon model in 3D](https://www.youtube.com/watch?v=6KJH1dG8qLY&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=6) | 8m, 36s |  |
| 7. [Adjacency matrix for undirected graphs](https://www.youtube.com/watch?v=YaxuxZiXnKI&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=7) | 15m, 08s |  |
| 8. [Adjacency matrix for directed graphs](https://www.youtube.com/watch?v=BBj-L2XDMno&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=8) | 21m, 08s |  |
| 9. [Digital image matrices](https://www.youtube.com/watch?v=q_TBd9qMEsg&list=PLSt7rwoPGTy0vfN0jsaAfiNEwaFfRFRVH&index=9) | 15m, 22s |  |

MATH 2B, Lesson 8

[Anatomy of Matrices](https://www.youtube.com/playlist?list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR) (18 Videos: 1h, 38m, 47s)

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| Video Title | Length | Complete |
| 1. [Introduction to matrix anatomy](https://www.youtube.com/watch?v=LZdT7lB0SzQ&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=1) | 09m, 59s |  |
| 2. [Example 1 of matrix anatomy](https://www.youtube.com/watch?v=XXRP9j5NHqw&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=2) | 04m, 51s |  |
| 3. [Definition of the leading entries of a row](https://www.youtube.com/watch?v=YOLzLjFIWso&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=3) | 05m, 32s |  |
| 4. [Definition of sparse matrices](https://www.youtube.com/watch?v=SD452-kOyGc&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=4) | 04m, 56s |  |
| 5. [Special sparsity structure notation](https://www.youtube.com/watch?v=yRHLsWtwhRs&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=5) | 08m, 48s |  |
| 6. [Definition of diagonal matrices](https://www.youtube.com/watch?v=hrnDWxUaB2U&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=6) | 03m, 04s |  |
| 7. [Definition of n-by-n identity matrix](https://www.youtube.com/watch?v=Dxm3Jn9TYBk&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=7) | 02m, 18s |  |
| 8. [Definition of lower-triangular matrix](https://www.youtube.com/watch?v=VrbI1fQ24BU&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=8) | 11m, 17s |  |
| 9. [Introduction to outer products](https://www.youtube.com/watch?v=hkmJbCsegCI&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=9) | 04m, 01s |  |
| 10. [Introduction to column and row partitions](https://www.youtube.com/watch?v=irINvCyICh0&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=10)  | 03m, 15s |  |
| 11. [Introduction to colon notation for the columns of a matrix](https://www.youtube.com/watch?v=_IdtP__kDe8&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=11) | 05m, 57s |  |
| 12. [Definition of the column operator](https://www.youtube.com/watch?v=cutxOuGuHQE&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=12) | 01m, 31s |  |
| 13. [The column partition of a matrix](https://www.youtube.com/watch?v=mRXzS_ZO6P4&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=13)  | 05m, 35s |  |
| 14. [When to use column partitions of a matrix](https://www.youtube.com/watch?v=dl0TEqmfYD4&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=14) | 07m, 53s |  |
| 15. [Colon notation for the rows and the row operator](https://www.youtube.com/watch?v=hATfINRtuq8&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=15) | 04m, 55s |  |
| 16. [The row partition of a matrix](https://www.youtube.com/watch?v=dWdgIL4Clec&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=16) | 02m, 30s |  |
| 17. [When to use row partitions of a matrix](https://www.youtube.com/watch?v=Ve_710ff7vI&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=17) | 09m, 50s |  |
| 18. [Column and row partition of the identity matrix](https://www.youtube.com/watch?v=rY0-bW8_L1w&list=PLSt7rwoPGTy1wOebU9RUT3t6lJGa7_FPR&index=18) | 02m, 35s |  |

MATH 2B, Lesson 9

[Matrix Arithmetic](https://www.youtube.com/playlist?list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr) (18 Videos: 1h, 57m, 33s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Definition of the outer product between vectors](https://www.youtube.com/watch?v=REaybRkV_4Q&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=1) | 05m, 21s |  |
| 2. [Example of matrix units as outer products](https://www.youtube.com/watch?v=nW8bDopfPd0&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=2) | 06m, 26s |  |
| 3. [Example of Gauss transform as an outer product](https://www.youtube.com/watch?v=qTraROS_VBs&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=3) | 02m, 22s |  |
| 4. [Why do we use column vectors so much?](https://www.youtube.com/watch?v=75O03b16j_M&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=4) | 02m, 16s |  |
| 5. [Scalar-matrix multiplication](https://www.youtube.com/watch?v=Lem7fz4qDnM&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=5) | 04m, 36s |  |
| 6. [Matrix-matrix addition](https://www.youtube.com/watch?v=MmsA78yWoFA&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=6) | 04m, 41s |  |
| 7. [Example of identity as matrix-matrix addition problem](https://www.youtube.com/watch?v=RsM3SuoD5Fo&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=7) | 03m, 00s |  |
| 8. [Write any matrix as a linear combination of outer products](https://www.youtube.com/watch?v=uUyC8DFFwF4&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=8) | 02m, 02s |  |
| 9. [Example of matrix addition in computational photography](https://www.youtube.com/watch?v=TjBYMN3h9v8&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=9) | 03m, 14s |  |
| 10. [Algebraic Properties of Matrix Arithmetic](https://www.youtube.com/watch?v=78YW22v4O0s&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=10) | 01m, 42s |  |
| 11. [Definition of a rank-one update](https://www.youtube.com/watch?v=5mVU_Bg3Arw&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=11) | 03m, 49s |  |
| 12. [Definition and examples of shear matrices](https://www.youtube.com/watch?v=zHaOJAEGq5o&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=12) | 11m, 50s |  |
| 13. [Definition and examples of dilation matrices](https://www.youtube.com/watch?v=_0vGZbwdPRg&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=13) | 11m, 27s |  |
| 14. [Definition and examples of transposition matrices](https://www.youtube.com/watch?v=OI2v27NNAvo&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=14) | 21m, 26s |  |
| 15. [Example of transposition matrix](https://www.youtube.com/watch?v=bN6CX1G-ZwY&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=15)  | 09m, 53s |  |
| 16. [Definition and examples of Gauss transforms](https://www.youtube.com/watch?v=V8N9K331_so&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=16) | 09m, 46s |  |
| 17. [Definition of the transpose of a matrix](https://www.youtube.com/watch?v=uvh0gcbCTDs&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=17) | 11m, 22s |  |
| 18. [Algebraic properties of the transpose](https://www.youtube.com/watch?v=PCTEaAkDUXA&list=PLSt7rwoPGTy1JuTPLGCWiVqMwQkEyEcjr&index=18) | 02m, 19s |  |

Lesson 10A:

[The Matrix-Vector Multiplication Problem](https://youtube.com/playlist?list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s) (13 Videos: 3h, 17m, 41s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [How to do matrix-column-vector multiplication via linear combinations?](https://www.youtube.com/watch?v=dqD1NJpO_WE&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=1) | 18m, 51s |  |
| 2. [Example of matrix-column-vector multiplication via linear combinations](https://www.youtube.com/watch?v=AtiOM9gailk&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=2) | 14m, 26s |  |
| 3. [How to do matrix-column-vector multiplication using dot products?](https://www.youtube.com/watch?v=VQ6rlUu9MTw&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=3) | 14m, 58s |  |
| 4. [Example of matrix-column-vector multiplication using dot products](https://www.youtube.com/watch?v=K_N7bsJh7bc&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=4) | 12m, 37s |  |
| 5. [Explore the algebraic properties of matrix-column-vector multiplication: scalar multiplication](https://www.youtube.com/watch?v=aa_zVe2CUyg&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=5) | 7m, 00s |  |
| 6. [Explore the algebraic properties of matrix-column-vector multiplication: distributivity](https://www.youtube.com/watch?v=-paPKeKktgA&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=6) | 22m, 59s |  |
| 7. [How to do row-vector-matrix multiplication via linear combinations?](https://www.youtube.com/watch?v=QYusQSFWiG0&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=7) | 12m, 06s |  |
| 8. [Example of row-vector matrix multiplication via linear combinations?](https://www.youtube.com/watch?v=FZvp6-ESwjE&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=8) | 11m, 28s |  |
| 9. [How to do row-vector-matrix multiplication using dot products?](https://www.youtube.com/watch?v=wmanefe3kBQ&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=9) | 13m, 30s |  |
| 10. [Example of row-vector-matrix multiplication using dot products](https://www.youtube.com/watch?v=DofWhxdqyL0&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=10) | 13m, 16s |  |
| 11. [What is the relationship between matrix-vector multiplication and matrix partitions?](https://www.youtube.com/watch?v=dEFlXJdeqVg&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=11) | 9m, 29s |  |
| 12. [Explore the algebraic properties of row-vector-matrix multiplication](https://www.youtube.com/watch?v=nbrizsZhVy8&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=12) | 21m, 24s |  |
| 13. [Do we really need four types of matrix-vector multiplication?](https://www.youtube.com/watch?v=7VidSUyR6Do&list=PLSt7rwoPGTy0W0tzVaqQh3RzlLVzTwW1s&index=13)  | 25m, 36s |  |

Lesson 11A:

[The Matrix-Matrix Multiplication Problem](https://youtube.com/playlist?list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD) (N Videos: Xh, Xm, Xs)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Introduction to matrix-matrix multiplication](https://www.youtube.com/watch?v=1yAZSlcZ2y8&list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD&index=1)  | 5m, 12s |  |
| 2. [The anatomy of matrix-matrix multiplication](https://www.youtube.com/watch?v=ocRQvFUYfLY&list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD&index=2)  | 8m, 32s |  |
| 3. [How to do matrix-matrix multiplication via linear combinations of column vectors?](https://www.youtube.com/watch?v=Apg8GERHvjA&list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD&index=3) | 14m, 47s |  |
| 4. [Example 1 matrix-matrix multiplication via linear combinations of columns](https://www.youtube.com/watch?v=AYuGi4232Y8&list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD&index=4) | 8m, 21s |  |
| 5. [Example 2 matrix-matrix multiplication via linear combinations of columns](https://www.youtube.com/watch?v=-v-_mD1uvms&list=PLSt7rwoPGTy1lVVAv-p0bVGsyQsqLqDGD&index=5) | 10m, 30s |  |
| 6. The matrix-matrix multiplication formula for the dot product | X |  |
| 7. [How to do matrix-matrix multiplication using linear combinations of row vectors?](https://youtu.be/7LuAFG36QQE) | 15m, 21s |  |
| 8. [Example 1 of matrix-matrix multiplication via linear combinations of rows](https://youtu.be/dcs_I9k7w5M) | 11m, 42s |  |
| 9. [Example 2 of matrix-matrix multiplication via linear combinations of rows](https://youtu.be/riYk2pF04eI) | 9m, 33s |  |
| 10. [How to do matrix-matrix multiplication using dot products?](https://youtu.be/MZcPtUkpkvs) | 20m, 57s |  |
| 11. Example 1 of matrix-matrix multiplication using dot products | X |  |
| 12. Example 2 of matrix-matrix multiplication using dot products | X |  |
| 13. How to do matrix-matrix multiplication using outer products? | X |  |
| 14. Example 1 of matrix-matrix multiplication using outer products | X |  |
| 15. Example 2 of matrix-matrix multiplication using outer products | X |  |

Lesson 11D:

[Matrix-matrix multiplication in action](https://youtube.com/playlist?list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY) (8 Videos: 1h, 55m, 23s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [The mathematician and her coffee pot](https://www.youtube.com/watch?v=L7G16CEWx6g&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=1) | 8m, 08s |  |
| 2. [Review of products in linear algebra](https://www.youtube.com/watch?v=ngBW5dnW65c&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=2)  | 17m, 02s |  |
| 3. [Elongation vector for mass-spring chain](https://www.youtube.com/watch?v=1tNDq8mP8Ds&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=3) | 20m, 08s |  |
| 4. [Net spring force vector for mass-spring chain](https://www.youtube.com/watch?v=SNFLM6KCsco&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=4) | 8m, 36s |  |
| 5. [Net force equation for mass-spring chain](https://www.youtube.com/watch?v=vrLf0nTojgs&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=5) | 18m, 34s |  |
| 6. [Matrix-matrix multiplication and mass-spring chains](https://www.youtube.com/watch?v=kv7zvJ-9RxQ&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=6) | 13m, 12s |  |
| 7. [Derivation of givens rotations](https://www.youtube.com/watch?v=gu7r4g0ZkOU&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=7) | 15m, 11s |  |
| 8. [Example of gauss transform in action](https://www.youtube.com/watch?v=8PZnYJGhlZ8&list=PLSt7rwoPGTy2dgt_2PEL5Jz1xAa-OMwIY&index=8) | 14m, 32s |  |

MATH 2B, Lesson 12

[The Nonsingular Linear Systems Problem](https://www.youtube.com/playlist?list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI) (24 Videos: 2h, 07m, 44s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Introduction to Nonsingular linear-systems problems](https://www.youtube.com/watch?v=5D8mksQ-qRE&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=1) | 06m, 12s |  |
| 2. [Example 1 of nonsingular system modeling gravity](https://www.youtube.com/watch?v=rtAvVY7WohA&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=2) | 05m, 57s |  |
| 3. [Set up of nonsingular matrix to model gravity](https://www.youtube.com/watch?v=uFEPiwjpdjw&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=3) | 10m, 34s |  |
| 4. [Set up of 5-by-5 backward substitution](https://www.youtube.com/watch?v=7gJBetgh9w0&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=4) | 04m, 33s |  |
| 5. [Step 0 of 5-by-5 backward substitution](https://www.youtube.com/watch?v=8cA52V_lvOg&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=5)  | 04m, 04s |  |
| 6. [Step 1 of 5-by-5 backward substitution](https://www.youtube.com/watch?v=VGRfWTO4L2E&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=6) | 02m, 59s |  |
| 7. [Step 2 of 5-by-5 backward substitution](https://www.youtube.com/watch?v=waW5BD0AcGM&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=7) | 06m, 46s |  |
| 8. [Final steps of 5-by-5 backward substitution](https://www.youtube.com/watch?v=xHRLP7-Cqj8&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=8) | 04m, 05s |  |
| 9. [General backward substitution algorithm](https://www.youtube.com/watch?v=cuVWs4f0LMQ&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=9) | 05m, 26s |  |
| 10. [Recall Nonsingular System Elimination for Gravity](https://www.youtube.com/watch?v=9PfrzaK-FIc&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=10) | 02m, 37s |  |
| 11. [How to Use Shear Matrix to Introduce Zeros](https://www.youtube.com/watch?v=YP8D2ZjDOxk&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=11) | 07m, 14s |  |
| 12. [Transform 3-by-3 to Upper-Triangular with 1st Shear](https://www.youtube.com/watch?v=k6ngUjGR8ck&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=12) | 05m, 44s |  |
| 13. [Transform 3-by-3 to Upper-Triangular with 2nd Shear](https://www.youtube.com/watch?v=LO1mLGMWVjU&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=13) | 09m, 20s |  |
| 14. [Does it Matter What Pivot We Choose](https://www.youtube.com/watch?v=Vtlepp4N6V0&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=14) | 03m, 44s |  |
| 15. [Transform 3-by-3 to Upper-Triangular with 3rd Shear](https://www.youtube.com/watch?v=YhQrBFd4sUA&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=15) | 05m, 58s |  |
| 16. [Use Backward Substitution to Solve 3-by-3 system](https://www.youtube.com/watch?v=5QHW4EEmPmY&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=16) | 06m, 23s |  |
| 17. [Solution to Gravity Modeling Problem](https://www.youtube.com/watch?v=RHlxZgv7osY&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=17) | 03m, 44s |  |
| 18. [Definition of a Regular Matrix](https://www.youtube.com/watch?v=vdcTXnRIY1g&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=18) | 02m, 10s |  |
| 19. [Solving Nonsingular Systems via Elementary Matrices](https://www.youtube.com/watch?v=wTY-pLdmjlY&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=19) | 04m, 41s |  |
| 20. [Are Elementary Matrices the Best We Have?](https://www.youtube.com/watch?v=6uTtKDpaCpo&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=20) | 04m, 06s |  |
| 21. [Overview of Applied Linear Algebra So Far](https://www.youtube.com/watch?v=es0anSKzcHI&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=21) | 04m, 46s |  |
| 22. [Intro to LU Factorization](https://www.youtube.com/watch?v=6dmEn_WUPaM&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=22) | 08m, 28s |  |
| 23. [Forward substitution for 4-by-4 lower-triangular system](https://www.youtube.com/watch?v=KeVgOsRoisk&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=23)  | 03m, 01s |  |
| 24. [General forward substitution algorithm](https://www.youtube.com/watch?v=6Z8JL2DIyW0&list=PLSt7rwoPGTy1A6nbePkWpXSfI7BgQkFZI&index=24) | 05m, 12s |  |

MATH 2B, Lesson 13

[Invertible Matrices](https://www.youtube.com/playlist?list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT) (13 Videos: 1h, 10m, 31s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Introduction to Invertible Matrices](https://www.youtube.com/watch?v=g41uXT2Vzvo&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=1) | 3m, 35s |  |
| 2. [First Example of Singular Matrix](https://www.youtube.com/watch?v=1EyFmQuvdXk&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=2) | 3m, 56s |  |
| 3. [Codomain and Range for Singular Matrix](https://www.youtube.com/watch?v=i4YtBy0w-G4&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=3)  | 4m, 34s |  |
| 4. [Nonsingular means linearly independent columns](https://www.youtube.com/watch?v=MA6nB0yDVTg&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=4) | 2m, 56s |  |
| 5. [Definition of Invertible Matrices](https://www.youtube.com/watch?v=-9O4hwBjCkQ&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=5) | 5m, 00s |  |
| 6. [Not All Square Matrices Are Invertible](https://www.youtube.com/watch?v=u2LiilJ2U9Y&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=6) | 4m, 48s |  |
| 7. [More Examples of Invertible Matrices](https://www.youtube.com/watch?v=lwEV1tDey6Y&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=7) | 6m, 42s |  |
| 8. [Invertible Diagonal Matrices](https://www.youtube.com/watch?v=KpwZSb37HZo&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=8) | 2m, 55s |  |
| 9. [First Hints of Invertible Matrix Theorem](https://www.youtube.com/watch?v=_MixKqEWOQ4&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=9) | 2m, 17s |  |
| 10. [Example of Inverse of a Shear Matrix](https://www.youtube.com/watch?v=B2mR2hld57Q&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=10) | 6m, 50s |  |
| 11. [Proof that Shear Matrices are Invertible](https://www.youtube.com/watch?v=4B9gVGRONrc&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=11) | 10m, 34s |  |
| 12. [Proof that Dilation Matrices are Invertible](https://www.youtube.com/watch?v=fKJCoamjMcY&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=12) | 11m, 25s |  |
| 13. [Conjecture- transposition matrices are invertible](https://www.youtube.com/watch?v=ewoWVH8ilbs&list=PLSt7rwoPGTy20T0gYYm2rzNkoNKYw9woT&index=13) | 4m, 59s |  |

MATH 2B, Lesson 14

[The Invertible Matrix Theorem](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub) (5 Videos: 24m, 08s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Introduction to the Invertible Matrix Theorem](https://www.youtube.com/watch?v=nMHj-qAiJDU&list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub&index=1) | 3m, 00s |  |
| 2. [The Invertible Matrix Theorem, Part 1](https://www.youtube.com/watch?v=E6TsELB1_Eg&list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub&index=2)  | 4m, 49s |  |
| 3. [The Invertible Matrix Theorem, Part 2](https://www.youtube.com/watch?v=Ko4PpR3Z6FM&list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub&index=3) | 6m, 10s |  |
| 4. [The Invertible Matrix Theorem, Part 3](https://www.youtube.com/watch?v=KHsOTY07r_k&list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub&index=4) | 5m, 19s |  |
| 5. [The Inverse of a Transpose](https://www.youtube.com/watch?v=i8-W3jC3SJI&list=PLSt7rwoPGTy0rvC69cYiEPNm4BAXGk0Ub&index=5) | 4m, 50s |  |

MATH 2B, Lesson 15

[LU Factorization without Pivoting](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf) (21 Videos: 1h, 44m, 43s)

|  |  |  |
| --- | --- | --- |
| Video Title | Length | Complete |
| 1. [Definition of LU Factorization](https://www.youtube.com/watch?v=frB3qWTvNLI&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=1) | 06m, 14s |  |
| 2. [LU Factorization Sparsity Structure](https://www.youtube.com/watch?v=Oyq_7w3wdsQ&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=2) | 02m, 35s |  |
| 3. [Inverse of a matrix product lemma](https://www.youtube.com/watch?v=fGFADyAi1XY&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=3) | 02m, 35s |  |
| 4. [Review of Nonsingular Gravity Model](https://www.youtube.com/watch?v=TLEHFZrI_GI&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=4) | 06m, 09s |  |
| 5. [Product of Pivot 1 Shears](https://www.youtube.com/watch?v=x4DXW8Xk-j0&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=5) | 09m, 37s |  |
| 6. [Shears from different pivots don’t mix well](https://www.youtube.com/watch?v=FNn5_bp4Cjs&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=6) | 04m, 03s |  |
| 7. [Sequence of L Matrices in Gravity Example](https://www.youtube.com/watch?v=F8Y0hqAO_yk&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=7) | 02m, 42s |  |
| 8. [Review of Gauss Transforms](https://www.youtube.com/watch?v=xTfCRifs6a8&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=8) | 04m, 16s |  |
| 9. [Inverting Gauss Transforms](https://www.youtube.com/watch?v=AhMLM6hUTS0&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=9) | 06m, 04s |  |
| 10. [Finding the L from LU](https://www.youtube.com/watch?v=Tbx9_GrxgII&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=10) | 06m, 48s |  |
| 11. [How to Use LU to Solve](https://www.youtube.com/watch?v=9AUPJgZ4aHE&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=11) | 03m, 00s |  |
| 12. [Forward Substitution in LU Solver](https://www.youtube.com/watch?v=8Z5oy80po-A&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=12) | 05m, 55s |  |
| 13. [4-by-4 LU Factorization Set Up](https://www.youtube.com/watch?v=owWahIXE4pw&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=13) | 03m, 14s |  |
| 14. [4-by-4 LU Factorization Pivot 1](https://www.youtube.com/watch?v=LT-NsiEfpxg&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=14) | 06m, 07s |  |
| 15. [4-by-4 LU Factorization Pivot 2](https://www.youtube.com/watch?v=yiV_JbLhqIo&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=15) | 05m, 15s |  |
| 16. [4-by-4 LU Factorization Pivot 3](https://www.youtube.com/watch?v=V0bP_0WQevw&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=16) | 03m, 10s |  |
| 17. [Proof of Inverse Gauss Transform](https://www.youtube.com/watch?v=yhp1rKMK3I0&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=17) | 09m, 20s |  |
| 18. [Form 4-by-4 Lower Triangular L](https://www.youtube.com/watch?v=MaAqGBuKZ9o&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=18) | 01m, 59s |  |
| 19. [Gauss Transforms Have Layers](https://www.youtube.com/watch?v=N8avSOL2SWc&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=19) | 05m, 46s |  |
| 20. [The Finished 4-by-4 LU Factorization](https://www.youtube.com/watch?v=O-ZbNyU8jKA&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=20) | 04m, 42s |  |
| 21. [Using the 4-by-4 LU Factorization to Solve](https://www.youtube.com/watch?v=eW5N2VqomXg&list=PLSt7rwoPGTy0xZQGqZjwAqqQhCjVBRcbf&index=21) | 05m, 12s |  |

Math 2B, Lesson 16

[Determinants](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX) (17 Videos: 1h, 31m, 06s)

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| Video Title | Length | Complete |
| 1. [Definition of Permutation](https://www.youtube.com/watch?v=ss_tg_hNznQ&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=1) | 05m, 36s |  |
| 2. [Symmetric group on one and two elements](https://www.youtube.com/watch?v=SO6B5ap3_0Y&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=2) | 06m, 02s |  |
| 3. [Symmetric group on three elements](https://www.youtube.com/watch?v=jf8eTeTK5yk&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=3) | 08m, 49s |  |
| 4. [Theorem: Transposition generate permutation](https://www.youtube.com/watch?v=z0BLwo70HZM&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=4)  | 03m, 58s |  |
| 5. [Review of Nonsingular Systems](https://www.youtube.com/watch?v=y2C6W8b0xVE&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=5)  | 04m, 45s |  |
| 6. [Checking nonsingularity can be painful](https://www.youtube.com/watch?v=WAIcrSwfQ58&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=6) | 04m, 48s |  |
| 7. [Dreaming of Determinants](https://www.youtube.com/watch?v=aMOyUiezUZM&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=7) | 03m, 55s |  |
| 8. [Deeper Dive into Nonsingularity](https://www.youtube.com/watch?v=HV0gVWdmgFQ&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=8)  | 07m, 18s |  |
| 9. [First Guesses about Determinant Function](https://www.youtube.com/watch?v=wTO0hT_DZb4&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=9) | 02m, 15s |  |
| 10. [Enter Area of Parallelogram](https://www.youtube.com/watch?v=2GjFD6Cxd6g&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=10)  | 04m, 33s |  |
| 11. [Derivation of 2-by-2 Determinant via Geometry](https://www.youtube.com/watch?v=HXmLeEsxaxI&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=11)  | 06m, 41s |  |
| 12. [Definition of 2-by-2 Determinant via Geometry](https://www.youtube.com/watch?v=LXiYVD8Z_wg&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=12)  | 01m, 40s |  |
| 13. [Conjectures for Elementary Matrix Determinants](https://www.youtube.com/watch?v=cvxGzs53n3o&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=13)  | 05m, 46s |  |
| 14. [Permutation Definition of Determinants](https://www.youtube.com/watch?v=cvxGzs53n3o&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=13) | 03m, 54s |  |
| 15. [Intro to Permutations for 2-by-2 Determinants](https://www.youtube.com/watch?v=dIcPWLV5Xrw&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=15)  | 06m, 11s |  |
| 16. [The sign of permutations in S2](https://www.youtube.com/watch?v=3b4e2NQt8KQ&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=16)  | 09m, 39s |  |
| 17. [Use Permutations to define 2-by-2 Determinants](https://www.youtube.com/watch?v=Q1amMdhdLUo&list=PLSt7rwoPGTy0_IFt6IVd09k2rjlLGNRJX&index=17) | 05m, 16s |  |

MATH 2B, Lesson 17

[The General Linear-Systems Problem](https://www.youtube.com/playlist?list=PLSt7rwoPGTy0CfEvz2txF0ww0TGjcD2Fz) (10 Videos: 1h, 53m, 12s)

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| Video Title | Length | Complete |
| 1. [The General Linear Systems Problem](https://youtu.be/ZHkS4QDRvvA) | 9m, 24s |  |
| 2. [The Gaussian Elimination Approach to Solving General Linear Systems](https://youtu.be/KkyTt43tH3w) | 7m, 18s |  |
| 3. [Definition of Row Echelon Form](https://youtu.be/aKxEABtOBKw) | 8m, 30s |  |
| 4. [Definition of Reduced Row Echelon Form](https://youtu.be/1C3Gspu2xtQ) | 5m, 25s |  |
| 5. [The Final Approach GLSP](https://youtu.be/oWGD1pSrbi4) | 5m, 59s |  |
| 6. [Set Up the Final Approach GLSP](https://youtu.be/lyLJ-P5vLw4) | 18m, 11s |  |
| 7. [Solve the Final Approach GLSP](https://youtu.be/GYoMJxxAYns) | 13m, 42s |  |
| 8. [Fourth Degree Model of a Potato Gun as a GLSP](https://youtu.be/dYDpoWbMPQ0) | 14m, 13s |  |
| 9. [Playing with a Toy General Linear Systems Problem](https://youtu.be/63D1xWFlvic) | 15m, 38s |  |
| 10. [Playing with a second toy general linear-systems problem](https://youtu.be/EJnLAco1uRU) | 14m, 49s |  |

MATH 2B, Lesson 18

[Solution Sets for the General Linear-Systems Problem](https://www.youtube.com/playlist?list=PLSt7rwoPGTy3qRgS9wMZTkWOMNqJ955Zx) (10 Videos: 2h, 25m, 43s)

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| Video Title | Length | Complete |
| 1. [The template for complete solutions to linear-systems problems](https://youtu.be/6126-_2J23A) | 10m, 55s |  |
| 2. [Example 1 of the template for complete solutions to linear-systems problems](https://youtu.be/WUF6-krfTCg) | 21m, 42s |  |
| 3. [Theorem: Elementary matrices preserve linear system solutions](https://youtu.be/jwr_S4Jh6vc) | 17m, 18s |  |
| 4. [Example 2 with more on the template for complete solutions to linear systems](https://youtu.be/4A6yl29SEAs) | 24m, 19s |  |
| 5. [Example 2, part 2: further exploring the unique, special trivial solutions](https://youtu.be/HqBdMkmFkyU)  | 13m, 11s |  |
| 6. [Theorem: Complete solutions to homogeneous linear-systems problems](https://youtu.be/bYz0d87qL1c) | 15m, 25s |  |
| 7. [Definitions of non)pivot positions, columns, and entries](https://youtu.be/5FHo4VYrca4) | 15m, 02s |  |
| 8. [Definitions of pivot variables and free variables](https://youtu.be/UkFxQeSumB4) | 8m, 49s |  |
| 9. [A general linear-systems problem from electric circuit analysis](https://youtu.be/X6q3ow1vn_0) | 12m, 15s |  |
| 10. [Notes about the rank of a matrix](https://youtu.be/u30AGP-eBa4) | 6m, 36s |  |

Jeff Anderson’s

Applied Linear Algebra

Advanced Applied Problems Playlists

LANA Project, Part 1

[Introduction to the Electronics Learning Laboratory Kit](https://www.youtube.com/playlist?list=PLSt7rwoPGTy3AiRIUGxesVeg-HHEYc9QZ) (12 Videos: 2 h, 5m, 3s)

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| Video Title | Length | Complete |
| 1. [Introduction to the Linear Algebraic Nodal Analysis Algorithm Learning Lab](https://youtu.be/R05zS0jlgTE) | 2m, 19s |  |
| 2. [The Electronics Learning Lab Kit for Linear Algebraic Nodal Analysis](https://youtu.be/OFzozmpSaX8) | 6m, 14s |  |
| 3. [What is a Solderless Breadboard?](https://youtu.be/sJ72h7Cubxk) | 13m, 23s |  |
| 4. [Introduction to Resistors](https://youtu.be/enbhIJwCEfI) | 13m, 56s |  |
| 5. [Introduction to DC Voltage Sources](https://youtu.be/8RzyCJ4smQ4) | 10m, 5s |  |
| 6. [Introduction to DC Current Sources](https://youtu.be/5BvSCfqUa44) | 6m, 6s |  |
| 7. [Let’s build our first circuit with a resistor and dc voltage source](https://youtu.be/3QrSn1TWCUk) | 9m, 25s |  |
| 8. [How do we measure the voltage drop across an element using a digital multimeter?](https://youtu.be/Vm6g8SZrrE8) | 12m, 7s |  |
| 9. [Some intuition about the voltage drop across an element](https://youtu.be/6pZOvRYU9ws) | 14m, 55s |  |
| 10. [What the heck is measurement polarity?](https://youtu.be/29ghHGeN58o) | 13m, 25s |  |
| 11. [How do we measure current using a digital multimeter?](https://youtu.be/rtAC-znQ1qE) | 7m, 55s |  |
| 12. [Measuring circuit variables: Example 1](https://youtu.be/7aSRQ68FQaI) | 15m, 33s |  |

LANA Project, Part 2

[Basic Concepts in Circuit Analysis](https://www.youtube.com/playlist?list=PLSt7rwoPGTy3_hJQHfFfwEzAJsmZIkXCA) (6 Videos: 1h, 41m, 45s)

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| Video Title | Length | Complete |
| 1. [Measuring Circuit Variables: Example 3](https://youtu.be/rqBD7svo8Ew) | 17m, 35s |  |
| 2. [Measuring Circuit Variables: Example 5](https://youtu.be/1NMsDn1Rdjg) | 14m, 44s |  |
| 3. [Parallel and Series Circuits](https://youtu.be/qSVL4h6bVQ0) | 11m, 11s |  |
| 4. [The Canonical Circuit Element](https://youtu.be/hrr4gng87lI) | 14m, 20s |  |
| 5. [The Nodes of a Circuit](https://youtu.be/oaW-Zk19m5Q) | 14m, 13s |  |
| 6. [Measuring Circuit Variables: Example 7](https://youtu.be/5tEZJRCf4fQ) | 29m, 42s |  |

LANA Project, Part 3

[Linear Algebraic Nodal Analysis: Example 2](https://www.youtube.com/playlist?list=PLSt7rwoPGTy3oR1622D-kgWIQvIMPg3sS) (16 Videos: 3h, 44m, 39s)

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| Video Title | Length | Complete |
| 1. [Linear Algebraic Nodal Analysis, Example 2: Circuit Model Verification](https://youtu.be/t3QL8KTcga0) | 14m, 31s |  |
| 2. [LANA Example 2, Step 1: Identify and label the entire set of nodes in our circuit](https://youtu.be/ABfvvq8NrDU) | 4m, 37s |  |
| 3. [LANA Example 2, Step 2: Model the circuit as a directed graph](https://youtu.be/aCu8avtPVDE) | 13m, 08s |  |
| 4. [LANA Example 2, Step 3: Create the entire incidence matrix](https://youtu.be/yYp5ds_TNKY) | 7m, 43s |  |
| 5. [LANA Example 2, Step 4: Create all circuit vectors](https://youtu.be/HcT9HtRDr0U) | 10m, 43s |  |
| 6. [LANA Example 2, Step 5A: State the entire set of KVLs in node potential form](https://youtu.be/iRIFrzJdkVE) | 16m, 02s |  |
| 7. [LANA Example 2, Step 5B: State the branch constitutive relations for the circuit](https://youtu.be/Nkbks715qxM) | 6m, 04s |  |
| 8. [LANA Example 2, Step 5C: State the entire set of Kirchhoff’s current laws](https://youtu.be/EOrdMdz0CnU) | 9m, 25s |  |
| 9. [LANA Example 2, Step 6: Determine all ordinary and generalized nodes](https://youtu.be/ot76Jn1PTbg) | 18m, 1s |  |
| 10. [LANA Example 2, Step 6 Extension Part 1](https://youtu.be/tia14a6Ho6w) | 22m, 59s |  |
| 11. [LANA Example 2, Step 6 Extension Part 2](https://youtu.be/4ASj2ZhvxmY) | 22m, 55s |  |
| 12. [LANA Example 2, Step 7: Ground the circuit](https://youtu.be/j10iZY0QLQ4) | 17m, 51s |  |
| 13. [LANA Example 2, Step 8: State the grounded circuit equations](https://youtu.be/EsQGa8GI17U) | 20m, 29s |  |
| 14. [LANA Example 2, Step 9: Identify (non)essential nodes and supernodes](https://youtu.be/PX39ylJyb4I) | 9m, 14s |  |
| 15. [LANA Example 2, Step 10: Eliminate node dependencies from voltage sources](https://youtu.be/-82zUcc2o4Q) | 17m, 48s |  |
| 16. [LANA Example 2, Step 11: State the maximally deflated circuit equation](https://youtu.be/jb1ZA8iLceM) | 13m, 02s |  |

LANA Project, Part 4

[Linear Algebraic Nodal Analysis Example 2, Proof of Nonsingularity](https://www.youtube.com/playlist?list=PLSt7rwoPGTy06KqgMb5c3mu2ggrG1VWqH) (4 Videos: 1h, 31m, 08s)

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| Video Title | Length | Complete |
| 1. [LANA Example 2, Step 11 Extension Part 1](https://youtu.be/6EEqFfxNX1E) | 20m, 02s |  |
| 2. [LANA Example 2, Step 11 Extension Part 2](https://youtu.be/EndDkGPuvQo) | 32m, 31s |  |
| 3. [LANA Example 2, Step 11 Extension Part 3](https://youtu.be/l6oORUkoh7c) | 14m, 57s |  |
| 4. [LANA Example 2, Step 11 Extension Part 4](https://www.youtube.com/watch?v=5FOY6tDIVTE) | 23m, 54s |  |

MATH 2B, Lesson 27

[How to use eigenvalues to model the real world?](https://youtube.com/playlist?list=PLSt7rwoPGTy2Jtf13gXh2MvSeo24xSgGv) 12 Videos: 3h, 48m, 13s

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| Video Title | Length | Complete |
| 1. [Introduction to the Standard Eigenvalue Problem](https://youtu.be/llaQL4tXqJY) | 29m, 05s |  |
| 2. [Introduction to the coupled pendula problem](https://youtu.be/UG7iPIxkzv4) | 5m, 40s |  |
| 3. [What is a McCusker apparatus?](https://www.youtube.com/watch?v=0rniYHmcg0k) | 5m, 23s |  |
| 4. [Visualizing the coupled pendula problem](https://youtu.be/5B23egrhzPs) | 11m, 27s |  |
| 5. [The formal statement of the coupled pendula problem](https://youtu.be/-s6hWWggTPk)  | 8m, 21s |  |
| 6. [Steps to Mathematize the Coupled Pendula Problem](https://youtu.be/DjQYJ5e-tFI) | 3m, 55s |  |
| 7. [Study the motion of a single pendulum](https://youtu.be/IT1EujqyCRM) | 21m, 45s |  |
| 8. [Derive the ordinary differential equation for a simple pendulum](https://youtu.be/DbeeJGu1kmc) | 37m, 44s |  |
| 9. [How to linearize the nonlinear ODE for a simple pendulum](https://youtu.be/Lcadejv383M) | 28n, 53s |  |
| 10. [Mathematical model for the coupled pendula problem](https://youtu.be/boefKSceZII) | 27m, 49s |  |
| 11. [State the coupled pendula ODEs using matrices](https://youtu.be/ZxtYt3d7ow4) | 14m, 22s |  |
| 12. [The standard eigenvalue problem to model coupled pendula](https://youtu.be/VmwWjVNNa3U) | 33m, 40s |  |

MATH 2B, Lesson 28

[Introduction to Eigenvalue Theory](https://youtube.com/playlist?list=PLSt7rwoPGTy3cjNAWNyGUHDfRkyZAa-qM)  5 Videos: 1h, 28m, 59s

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| Video Title | Length | Complete |
| 1. [Solving the coupled pendula standard eigenvalue problem](https://youtu.be/uhu0AAxrnEs) | 27m, 30s |  |
| 2. [The Story of Eigenvalue Education, Part 1](https://youtu.be/CJ5FxXUszRc) | 18m, 50s |  |
| 3. [The Story of Eigenvalue Education, Part 2](https://youtu.be/T1xQbxEk4sE) | 7m, 40s |  |
| 4. [Case studies of eigenvalues of 2-by-2 matrices: Analyze, Categorize, Relate](https://youtu.be/mcH_iJtksU8) | 9m, 43s |  |
| 5. [When is a 2-by-2 symmetric matrix positive definite?](https://youtu.be/MRHmgawP3kM) | 25m, 11 |  |