Computer Graphics for Better Understanding and Student Comprehension

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About me.

- BS-Electrical Engineering, University of Delaware
- MS-Elec. Comp. Engineering, Carnegie Mellon University
- Ph.D., Imaging Science, RIT

- **Licensed Magician**
- Gardener
- Wood working
- Ceramicist / Potter
- Trained Suicide Helpline Staff
- Director of the Computer Petting Zoo

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Important:

- I wrote the first digital image file format converter for Eastman Kodak Company.
- TIFF – Tag Image File Format.
- I wrote the first JPEG files that were JPEG compliant.

- I have been doing computer graphics since 1972.

- The "Personal Computer" did not happen until ~1983. (Apple IIe)

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The Problem For Today:

At RIT, does not have
a graphics Arts department.

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Possible Solutions:

- Skip it.

- When you get a grant,
  include money for a graphic artist.

- Do it yourself

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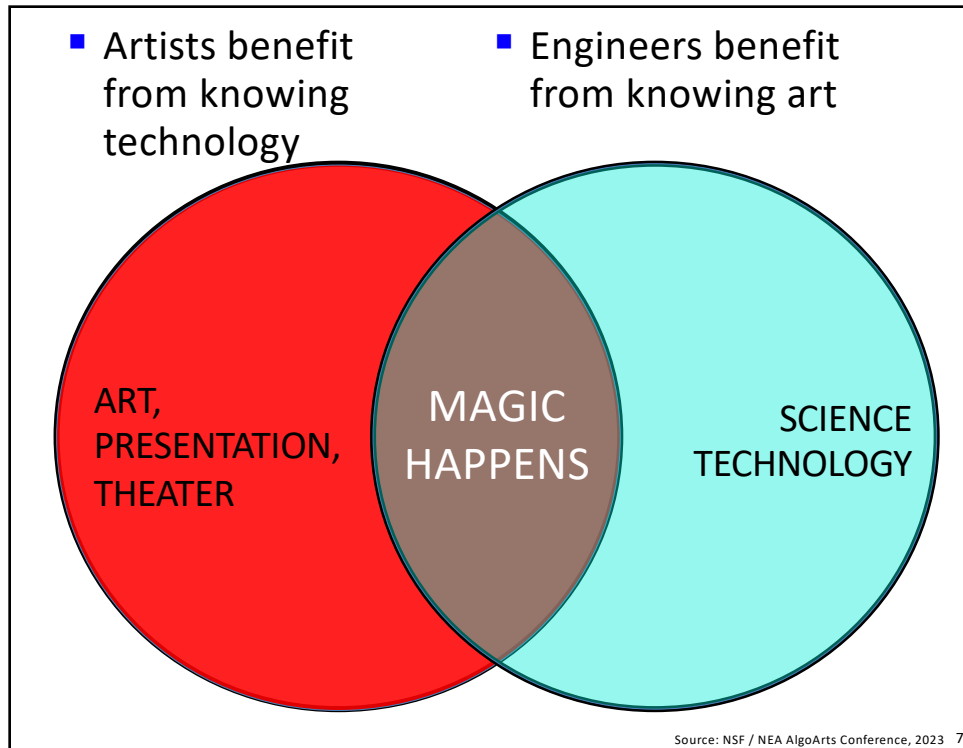## Why: Integrating artwork leads to:

1. Increased critical thinking abilities
2. Higher-order comprehension and deeper learning
3. Increased content mastery
4. Problem solving skills
5. Teamwork and communication skills
6. Improved visuospatial reasoning
7. General engagement and enjoyment of learning

    Source: NSF / NEA AlgoArts Conference, Monday May 15th-16th, 2023

8. It saves tons of time.

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- Artists benefit from knowing technology
- Engineers benefit from knowing art

ART, PRESENTATION, THEATER

MAGIC HAPPENS

SCIENCE TECHNOLOGY

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Considerations - Psychology:

- What is the audience?
- What *insights* do you want to share?
- Are there viewing constraints?
  - Font Size
  - Projector Size?
  - Is there light outside?
  - What will the contrast on the screen be like?

- What *story* are you trying to share?

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Stories

A. When we tell a story, we are *storing information* in another person, outside of yourself

B. You might be extremely creative

C. That other person might remember the information better than you can

D. Use *collective knowledge*

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Considerations – Technicality:

▪ What are you doing? Presentation? Paper?

▪ What technologies do you need?
   o 2D?
   o 3D?
   o Video?
   o Interactive?
   o Audience participation?

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Phases

A. How much time do you have?
B. Ideation and Storyboarding
C. Managing cognitive load
D. Considerations for colorblind students
E. Software options
F. Development
G. Deployment
H. Testing and refinement

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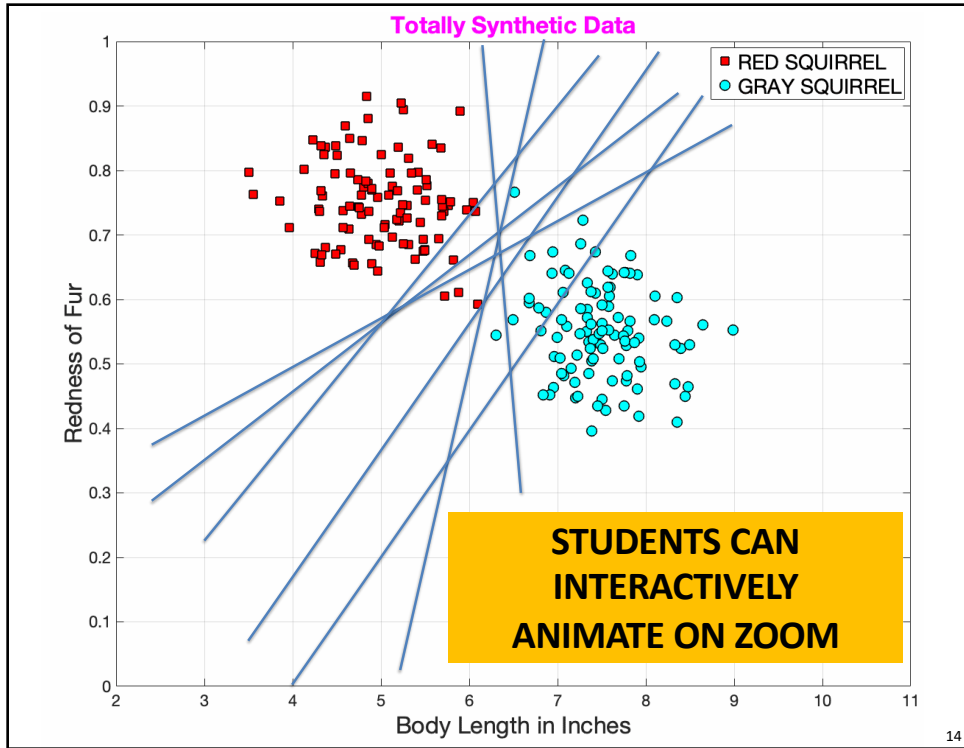

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There is the origin.

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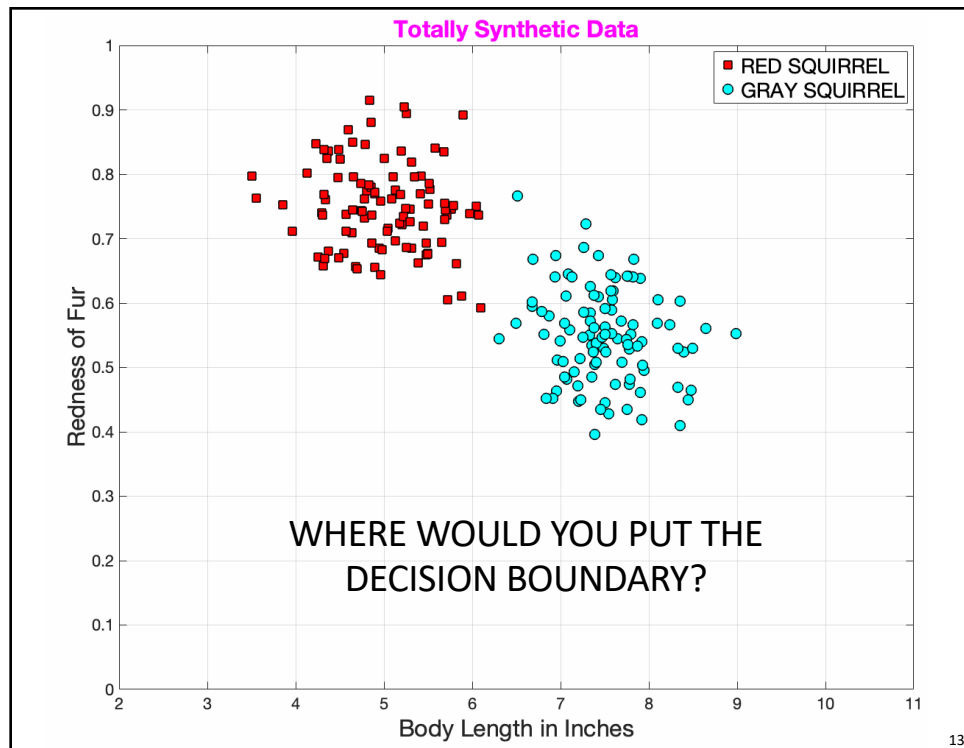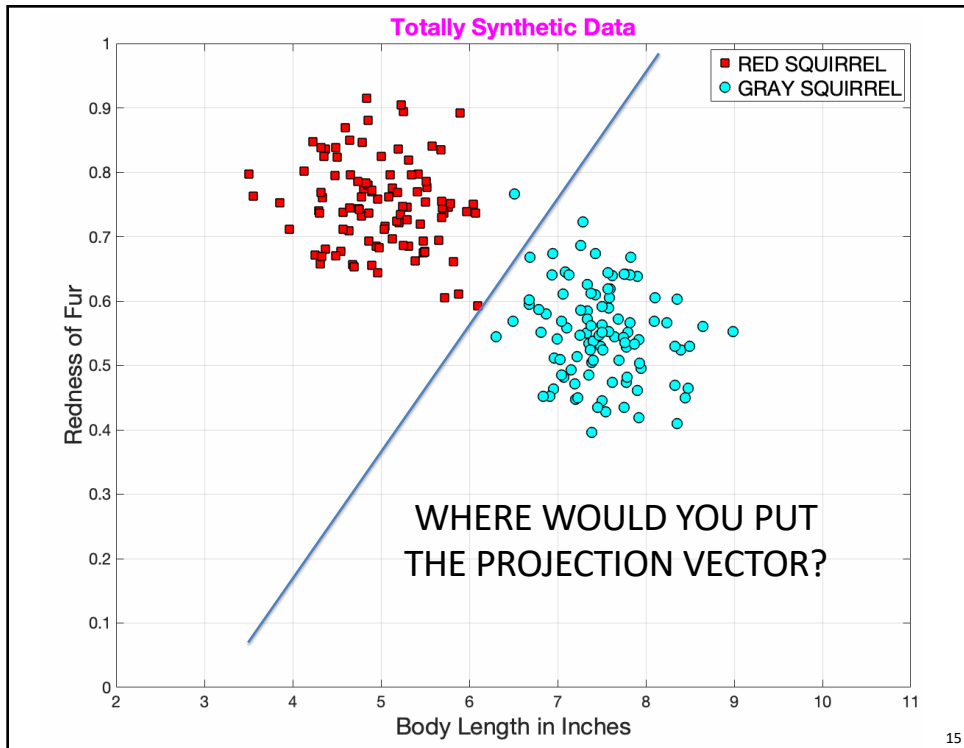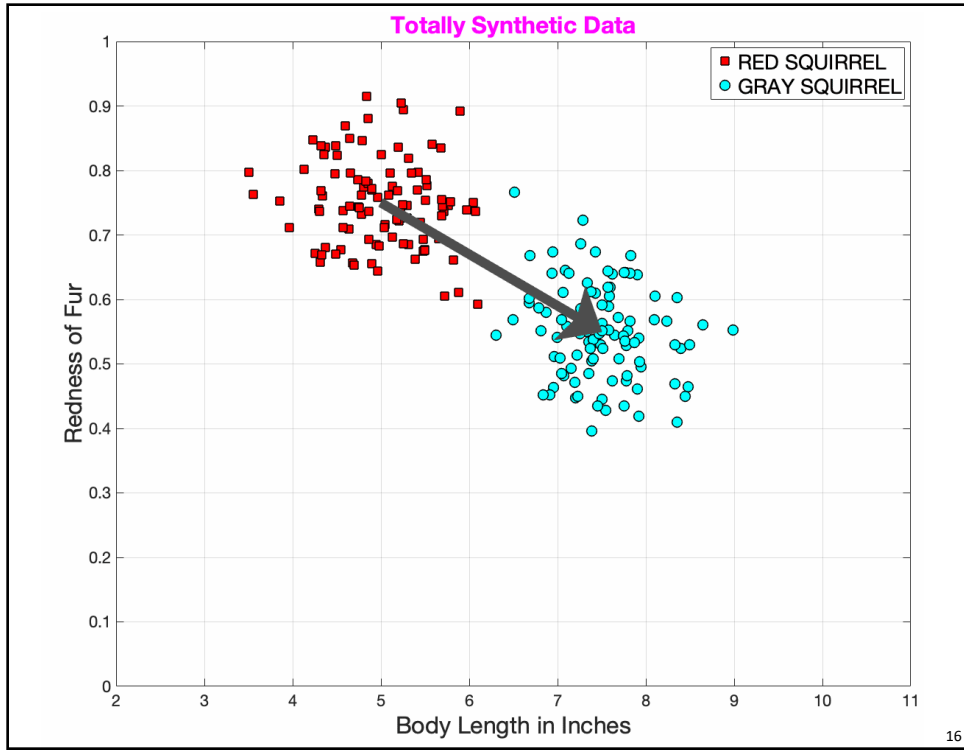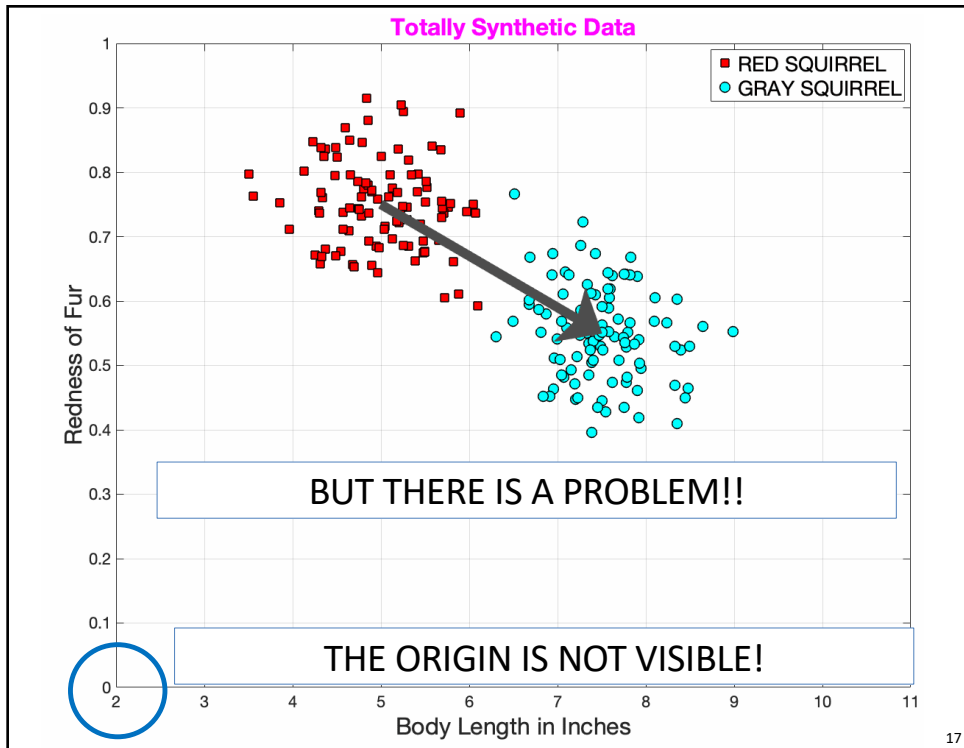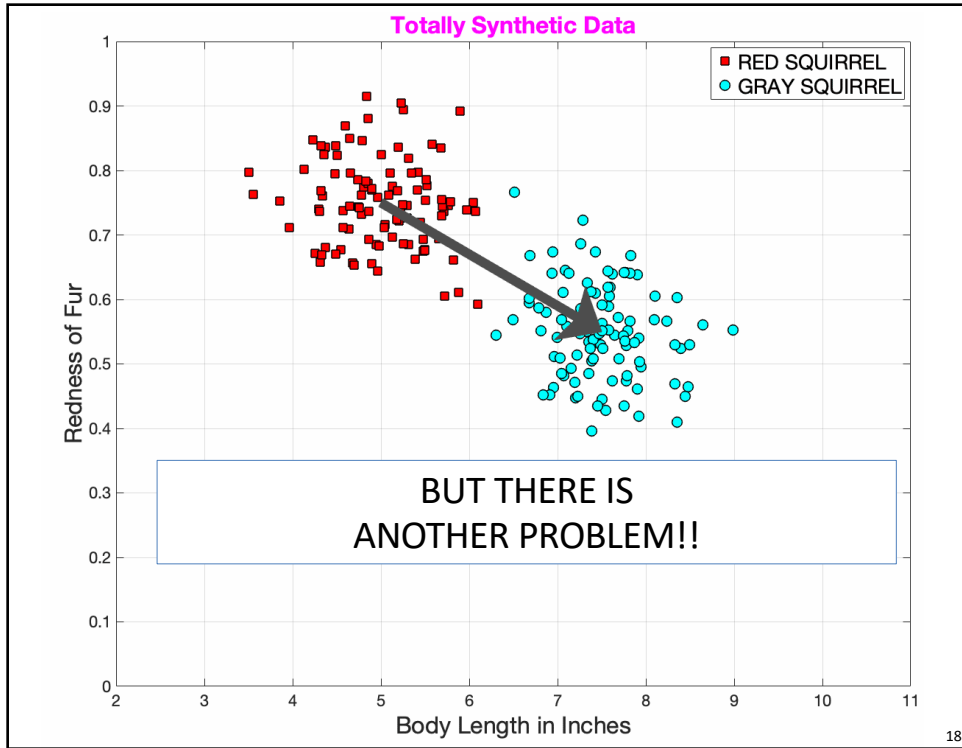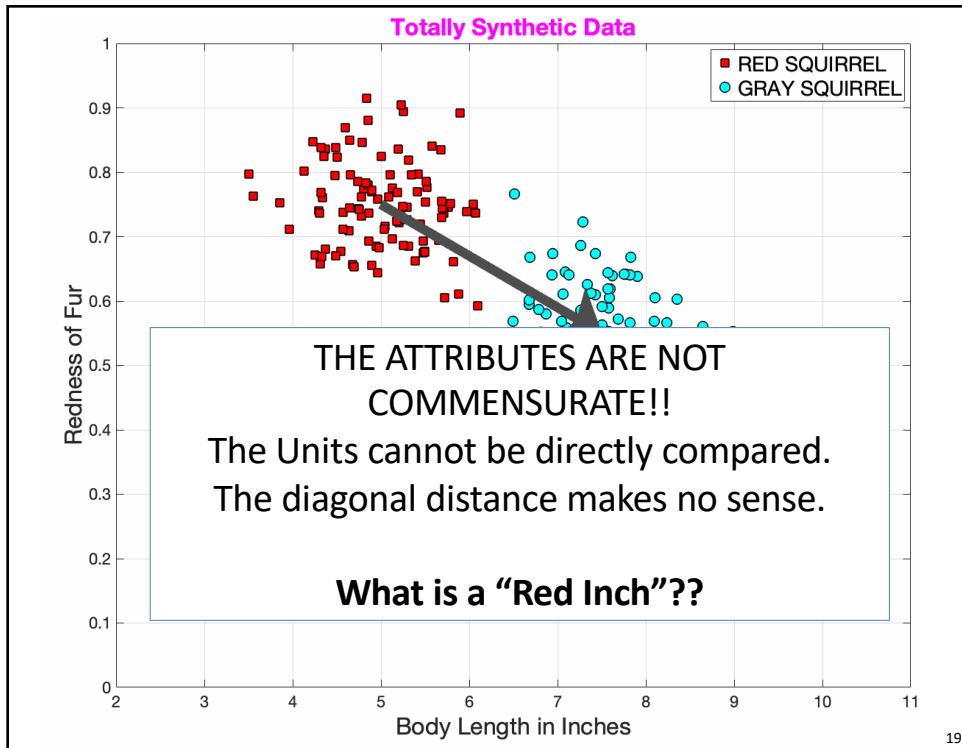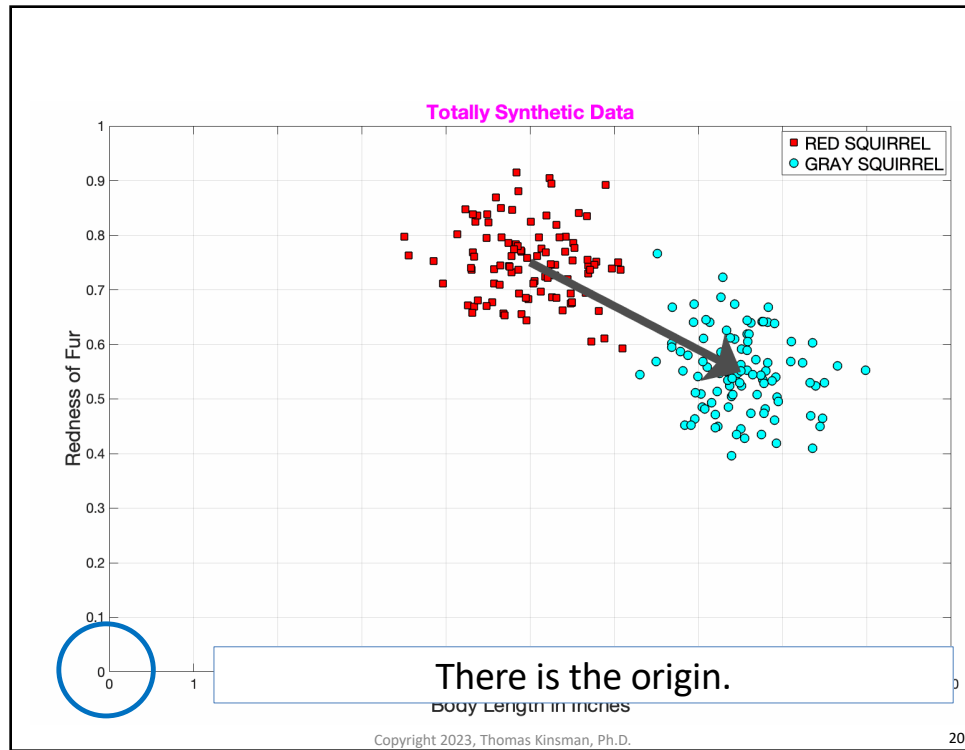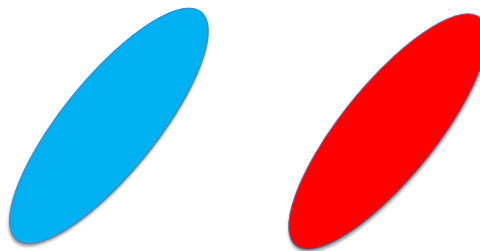
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Use Native Support if Possible:

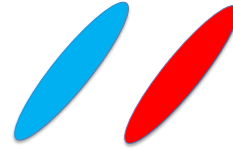In PowerPoint I can use simple circles that are stretched and rotated to form ellipses:
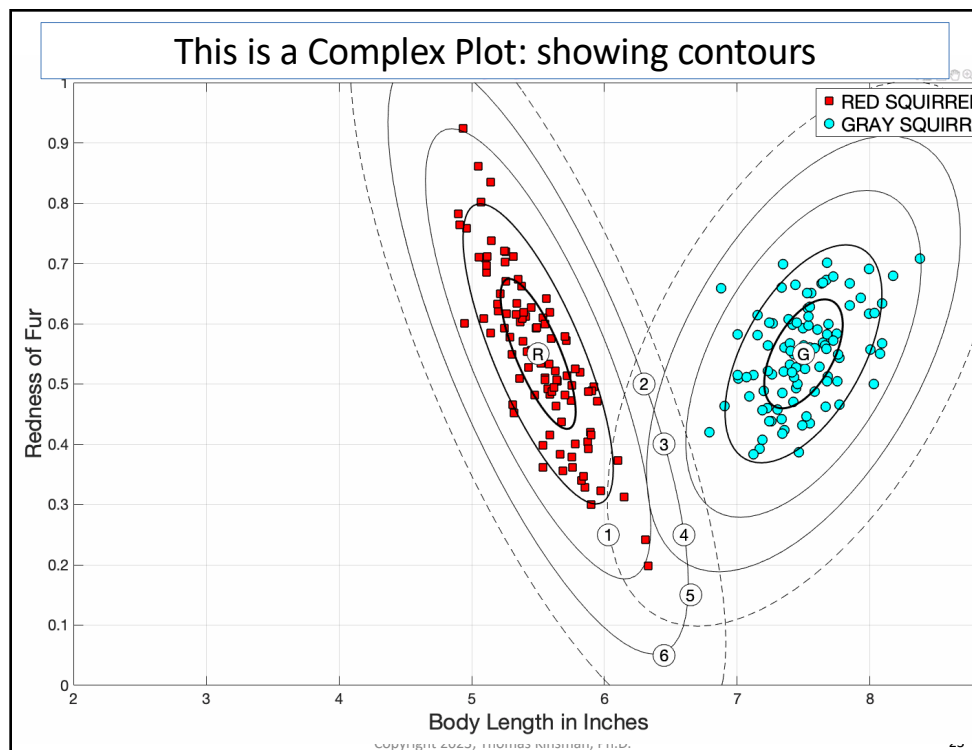
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Color Blind Solutions

- At RIT,
  - 1/13 of males are colorblind.
  - 1/169 females are colorblind.
  - More colorblind than deaf.
- Avoid Green, Red, Pink.
- Use Black on White:
- Use Brownish-Red, and Blue.
- YELLOW is a highlight color.
- Use contour plots.

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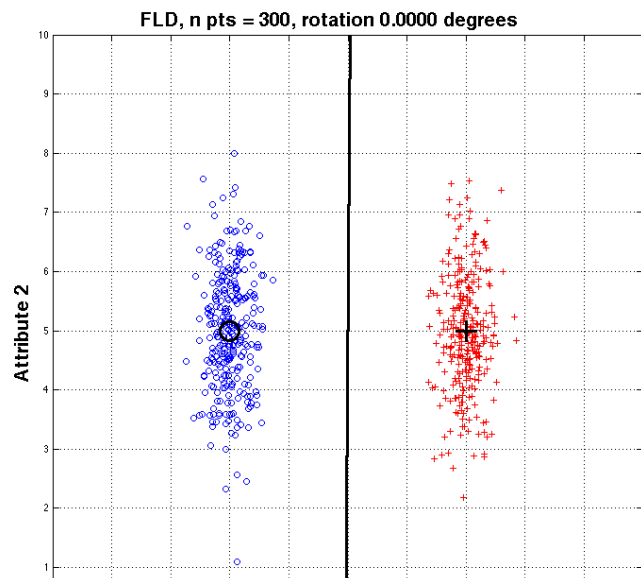This is a Complex Plot: showing contours

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Demonstrating an Animation

- The following figures were generated using a package, one frame at a time.

- Development:
  Get things working for one frame,
  then run it for many frames.

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FLD, n pts = 300, rotation 0.0000 degrees

PROBLEM: 2D animations are not seen by students who only look at the PDF's.

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This slide shows "key frames" from the animation for
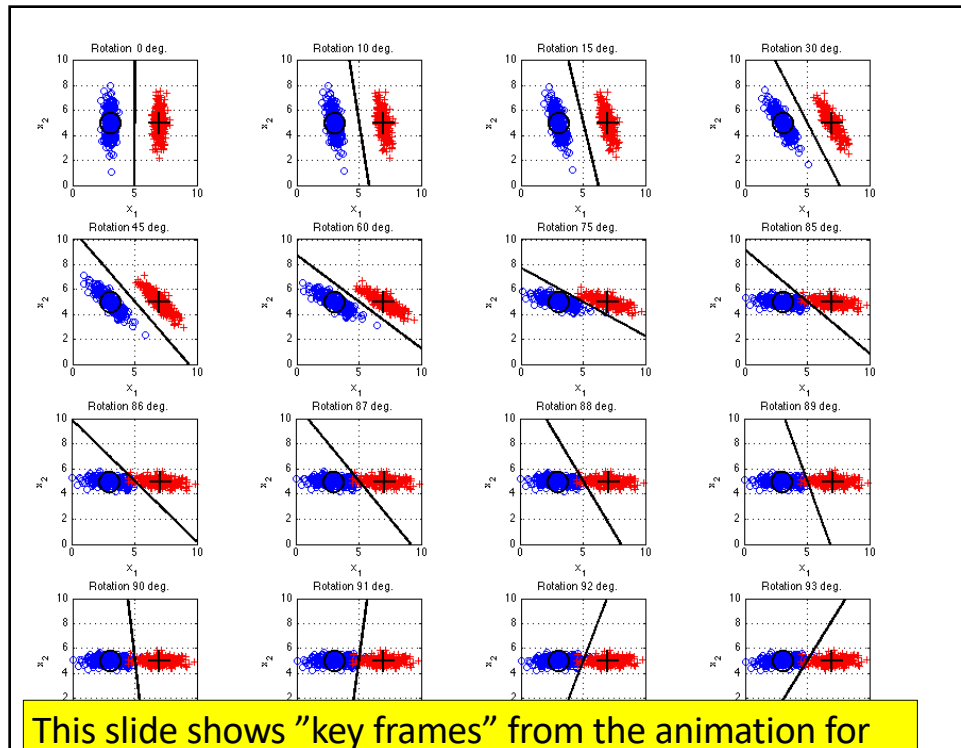
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Status Check!

- What fraction of the information in a lecture will students retain, just by watching the lecture?

- About five percent is the number thrown around.

- Yet, students have what I term, "*the illusion of understanding.*"

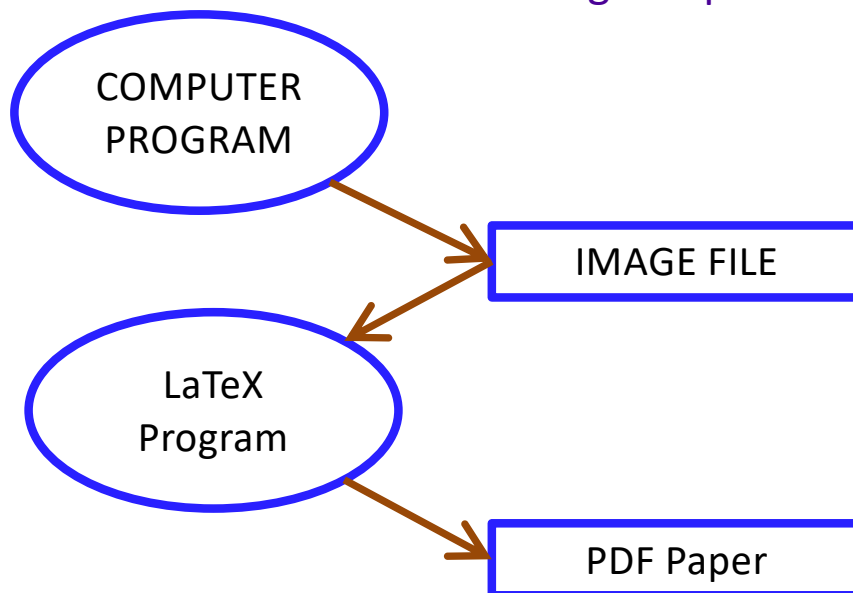27

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Development Steps:

1. I am going to write a program.

2. The program creates a graphics file:
   - a diagram
   - a figure
   - an image. (all the same thing.)

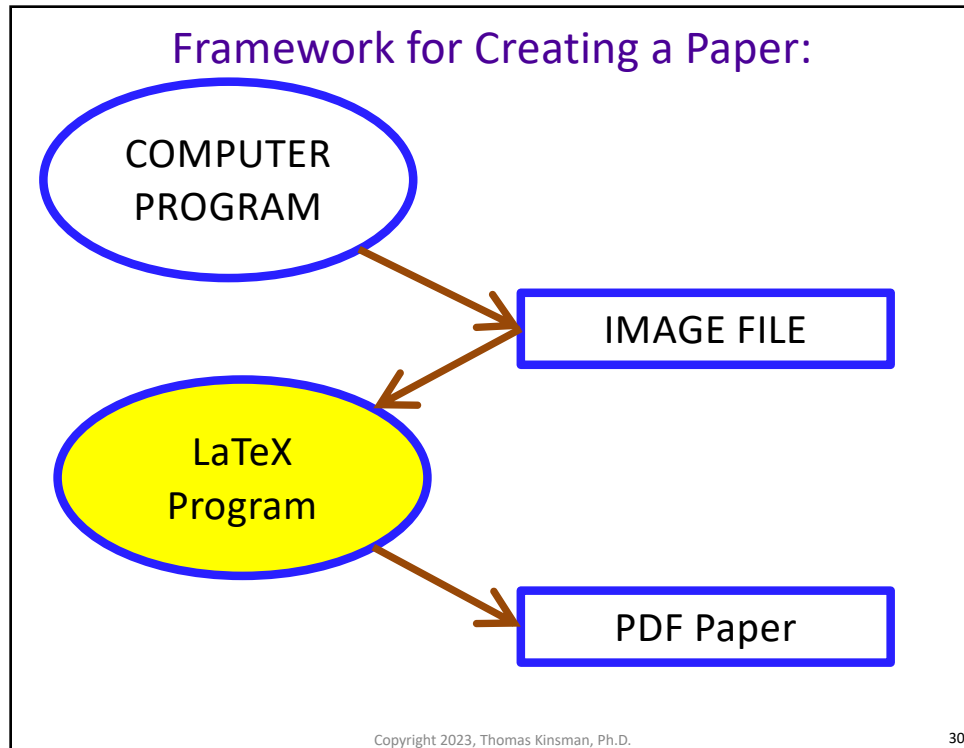3. The file is pulled straight into my LaTeX paper.

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Framework for Creating a Paper:

COMPUTER PROGRAM → IMAGE FILE → LaTeX Program → PDF Paper

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Framework for Creating a Paper:

COMPUTER PROGRAM

IMAGE FILE

LaTeX Program

PDF Paper

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Example pulling file into LaTeX Paper:

```
\begin{figure}

\centering

\includegraphics[width=0.6\textwidth]
{My_Figure_Name.eps}

\caption{Exactly what I want the
viewer to see!}

\label{fig_Label_For_Cross_Ref}

\end{figure}
```

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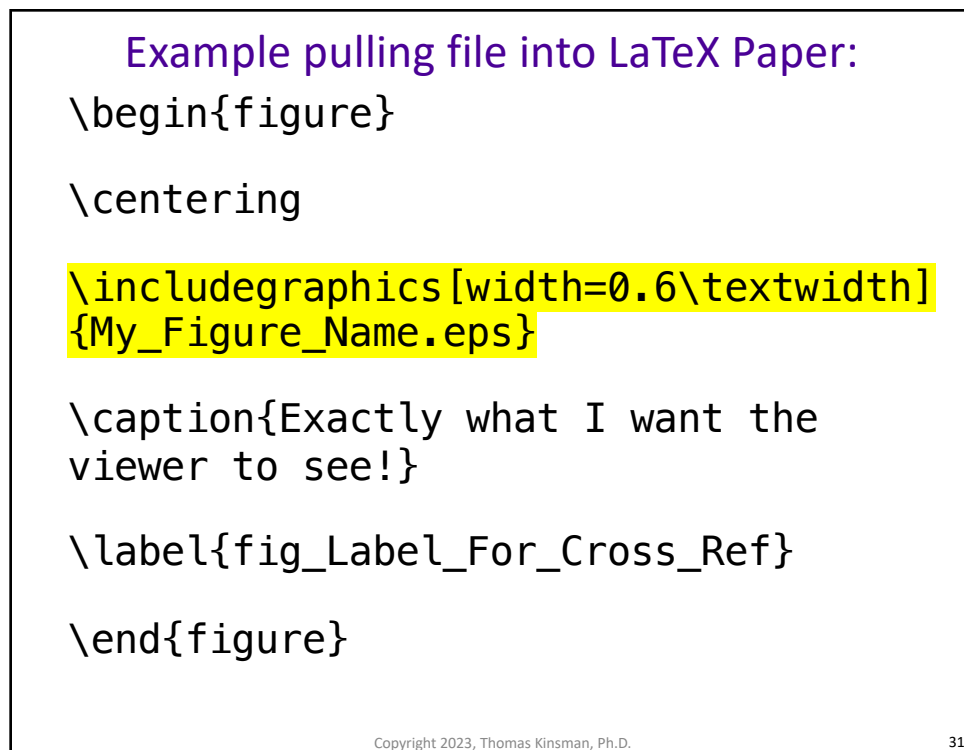
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So What?

- If I am creating a power point, I can drag-and-drop the figure directly into my presentation.

- <u>Now you know why I bother.</u>

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Part II

Programming Discussion

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Find a working example:

- Look through your resources

- Find an example that is as close to what you want to do as possible

- Start with that

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All Programs Have a Core Method:

- plot(x_locations, y_locations)

--- or ---

- plot3(x_locations, y_locations, z_locations)

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Possible Programming Languages

- Excel
- Power-VI
- Matlab
- python
- Sketch
- Mathematica
- Many others
- For native to LaTeX:
  - ticz
  - asymptote - for interactive 3D drawings

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Possible Image File Formats:

- TIFF   Tag Image File Format
- JPEG   Joint Photographic Experts Group
- PNG   Portable Network Graphics
- GIF   CompuServe Image Format
- SVG   Scalable Vector Graphics
- PS   PostScript
- EPS   Encapsulated PostScript

- Many others

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Two Programming Paradigms:

A. Using the current pen color
and the current attributes.

- Everything about the line is defined ahead of time: width, color, style.
- Everything must be defined ahead.

B. Describe the current pen color
for every single line.

- All attributes are defined every single time you create a line

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- **All attributes are defined every single time you create a line**

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Possible Drawing Coordinates:

- Absolute:
  - I first define a coordinate system, and then tell you were to put the lines in it.

- Relative:
  - Wherever the "current pen position" is, draw the diagram or line with respect to the last thing drawn.

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Matlab Example:

- Uses absolute coordinates:
- User Red-Green-Blue color specifications.
- Includes graphic display.

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Strategy to Install Matlab:

- At RIT Google for
  Software for Personal Computers
  site:rit.edu

- Follow the procedure

A *strategy* is different than a procedure.

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```matlab
function Gen_1D_Vanilla_Plot_v01( )
   % Step 1: Create a Figure:
   figure( 'Position', [10 10 1024 350 ]);

   % Step 2: Get or Create your Data:
   xs = -10 : 0.1 : 10;            % for x = minus 10 to 10
   ys = gaussian_tbk( 0, 1, xs); % some function

   % Step 3: Plot on the figure:
   plot(xs, ys, 'LineWidth', 5);

   % Step 4: Decorate the figure:
   ylabel('Probability', 'FontSize', 20);
   title('Gaussian Probability Distribution', …
         'FontSize', 24);

   % Step 5: Save the Figure:
   print('-deps', 'Fig_Gauss_Distribribution.eps' );
end
```
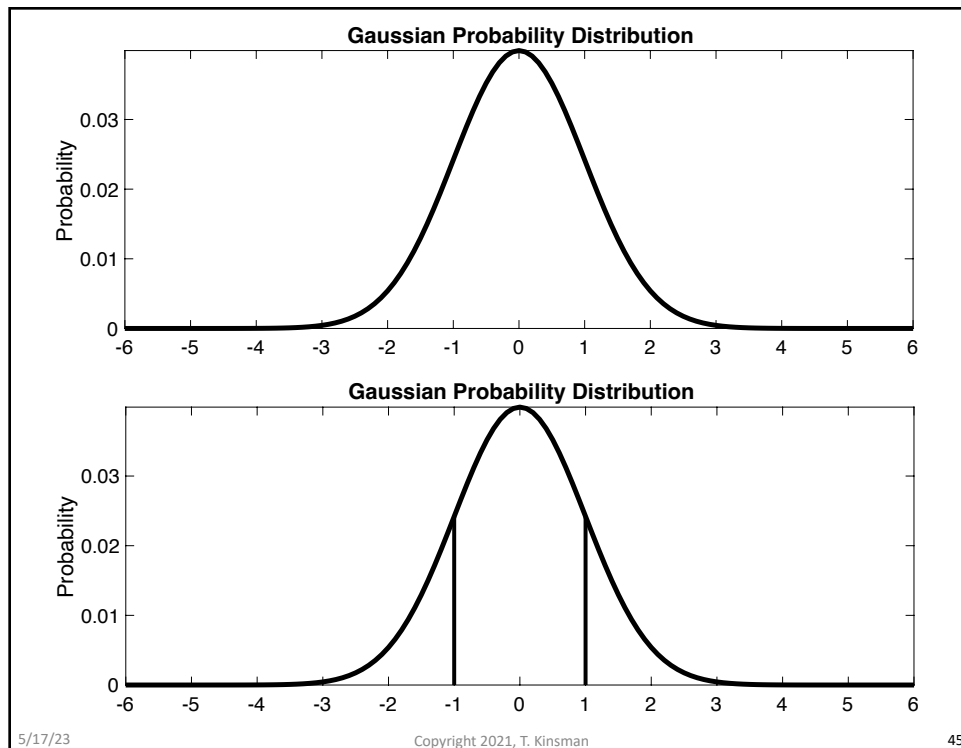
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Gaussian Probability Distribution / ← Gaussianly Distributed Data →

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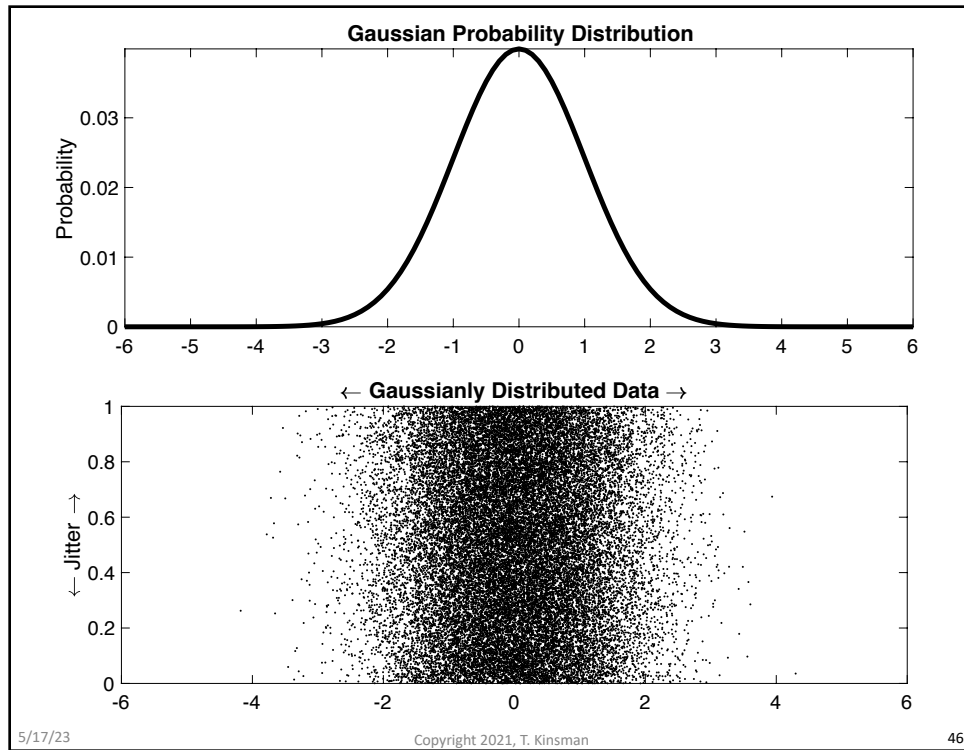
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Active Learning:

HAVE STUDENTS SKETCH THE GRAPHS BY HAND!

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Pizza

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Everyone Likes Pizza

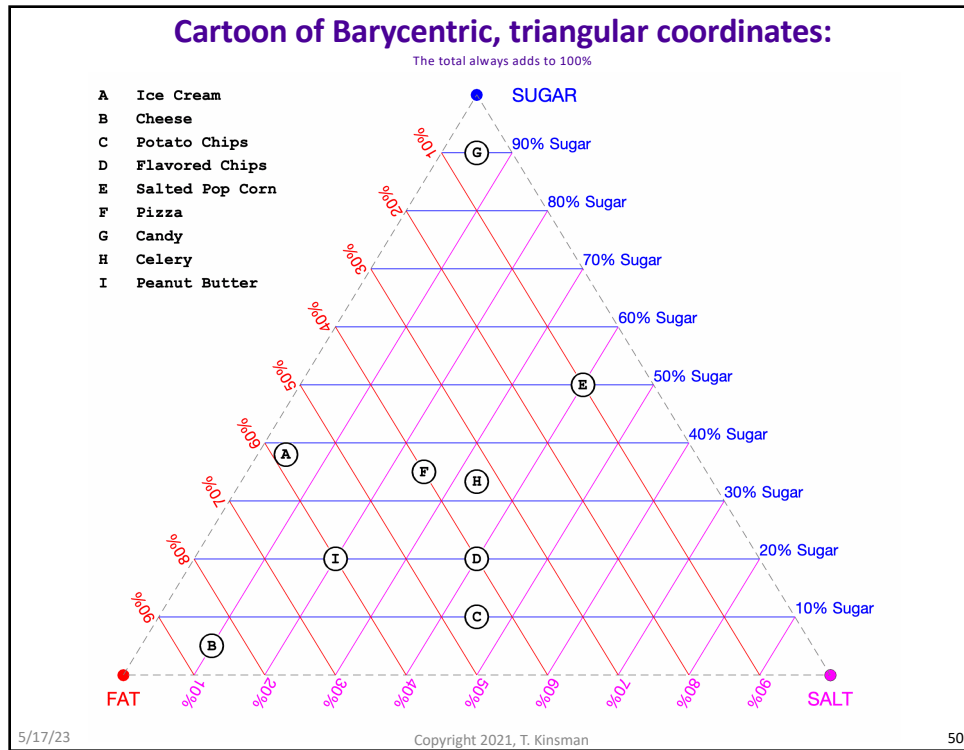- Pizza is the perfect combination of:
  - Salt
  - Fat
  - Sugars

- It is the "triple point" for food science.

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Cartoon of Barycentric, triangular coordinates:

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Getting Rich on Pizza

- We are going to use Data Science to make _perfect_ pizza.

- In my kitchen, I can make 10 different pizzas a week and sample them.

- I will make them with 10 different amounts of cheese.
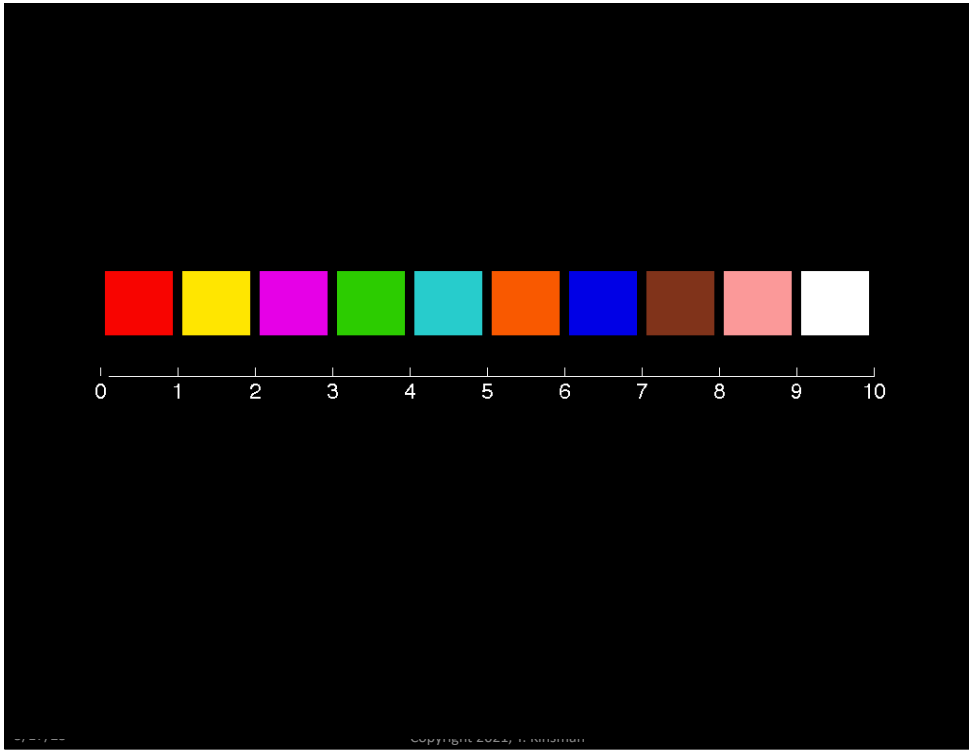
- So, cheese is one dimension, or attribute:

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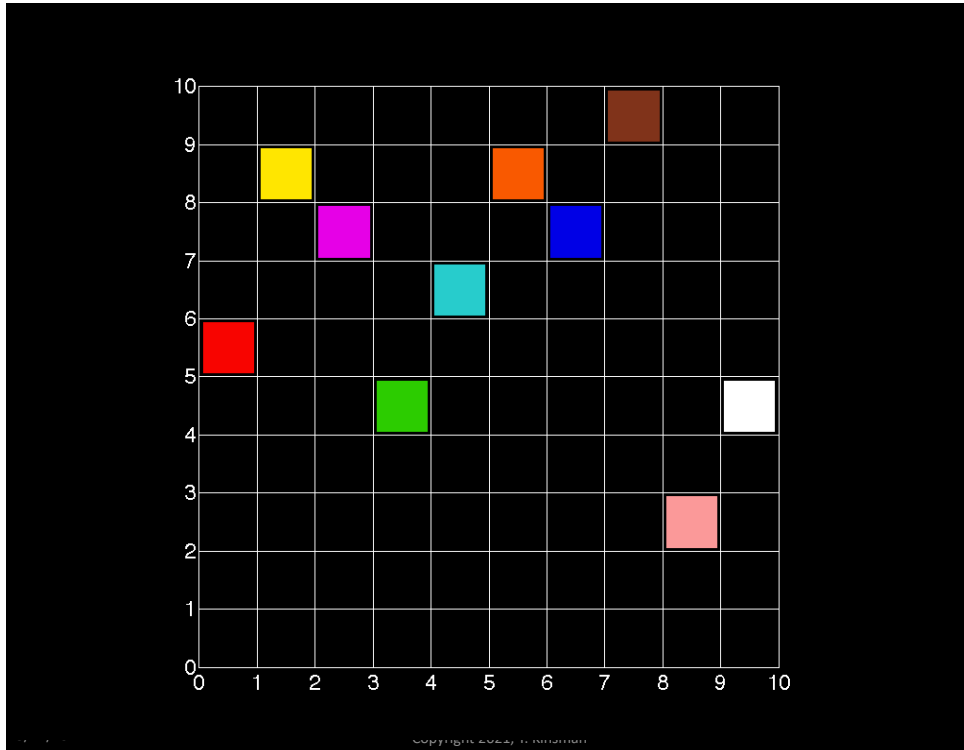## Curse of Dimensionality:
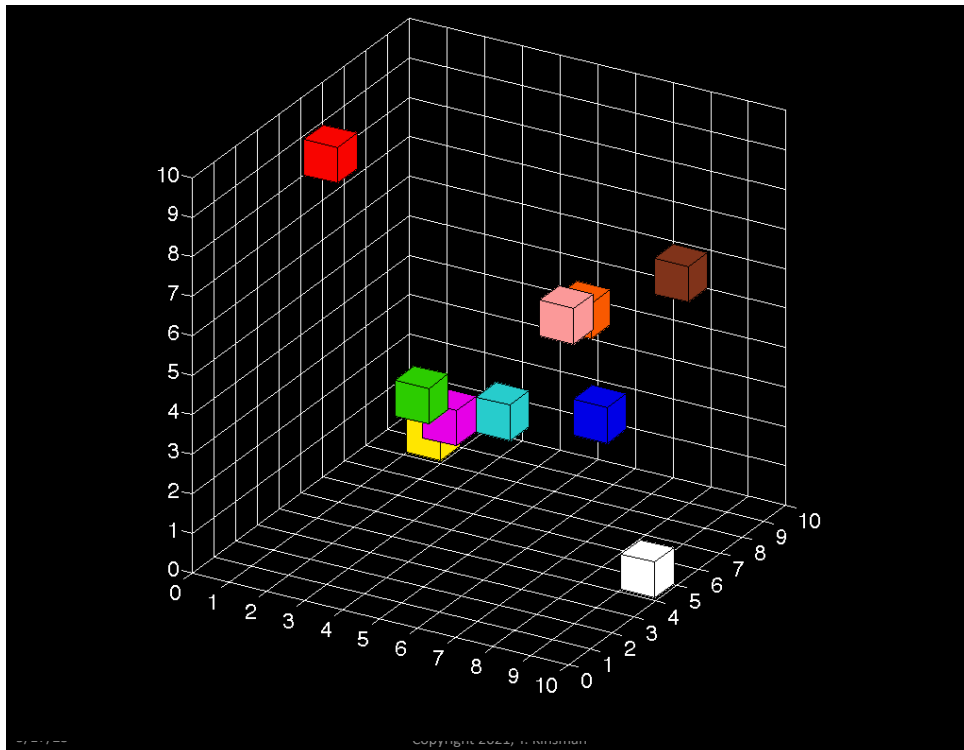Given a Gaussian Distribution in N-Dimensional Feature Space, how far are the samples scattered?

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Density Changes
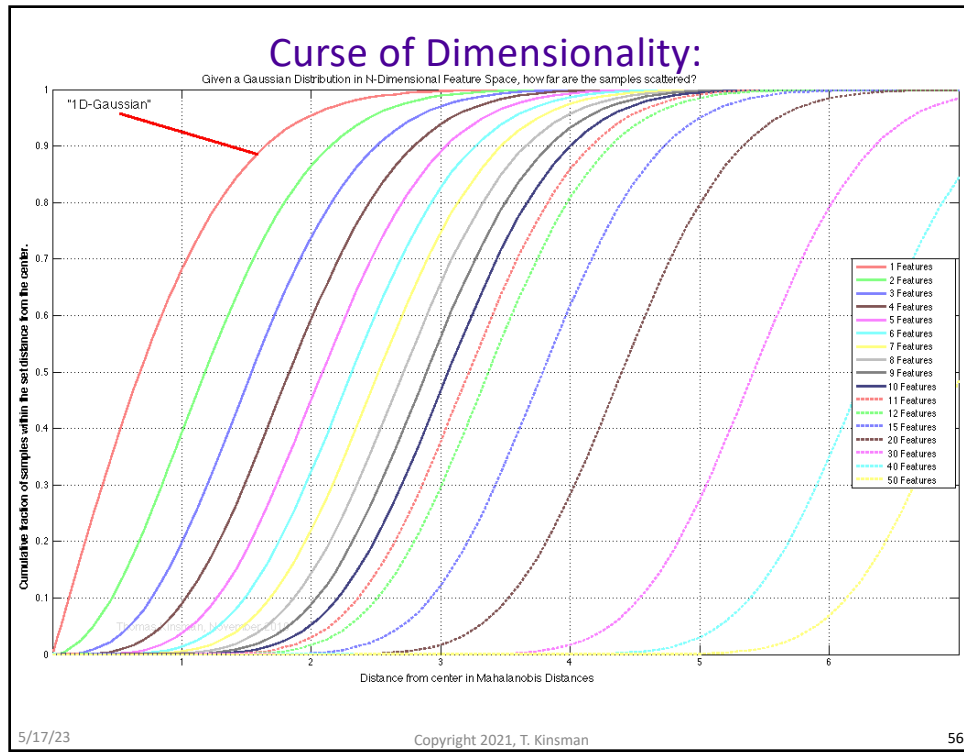
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Mahalanobis Distance as Density Change

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Density Change as Contour Plots
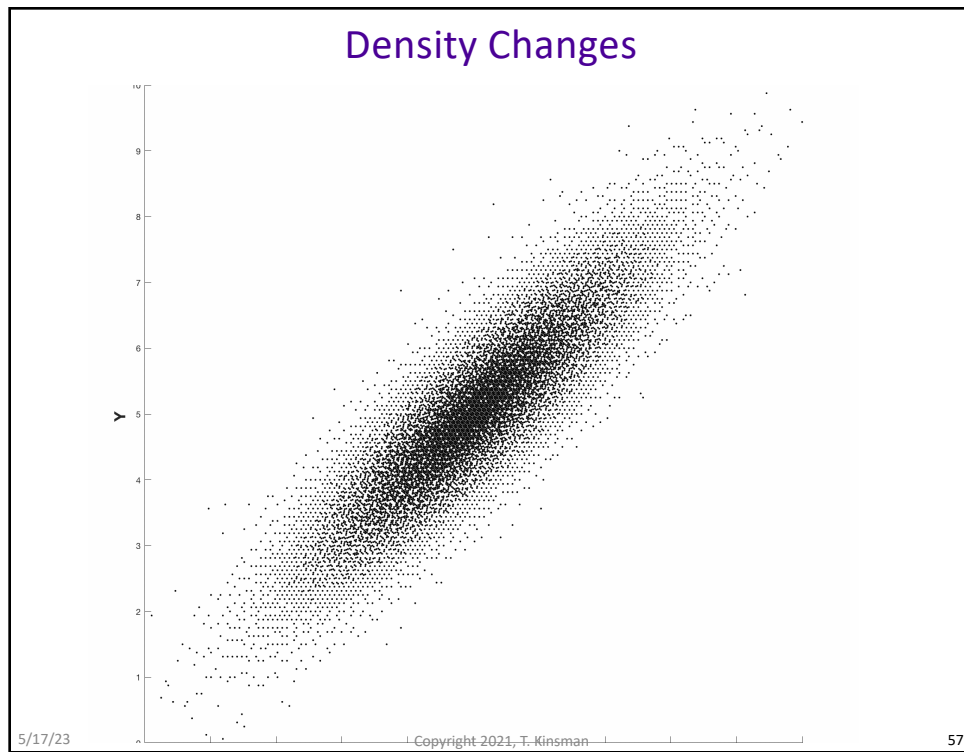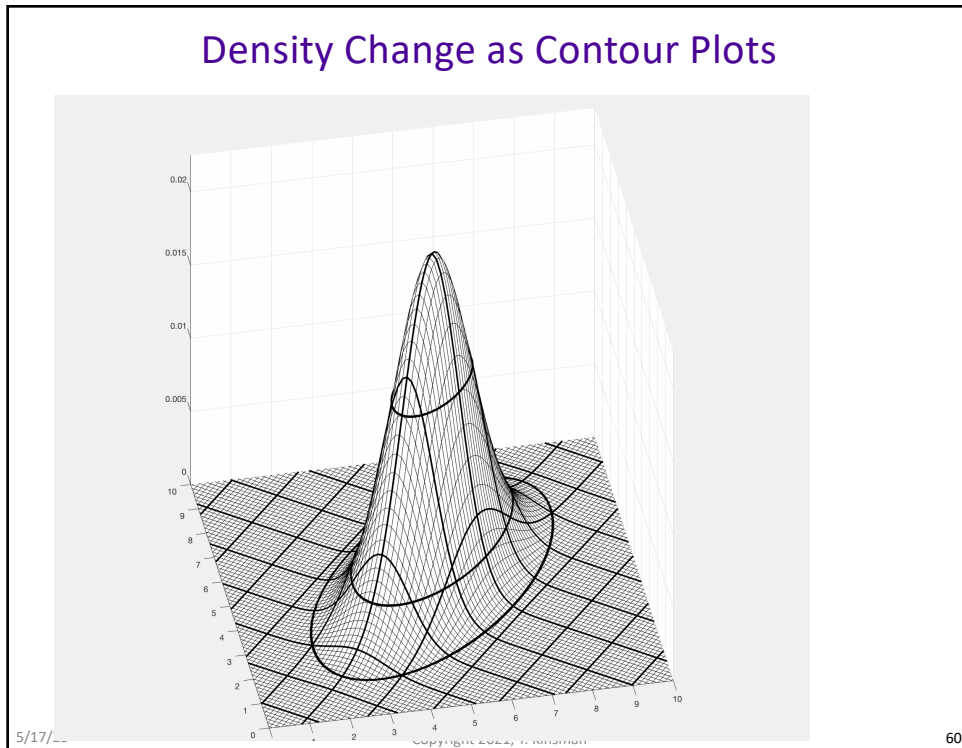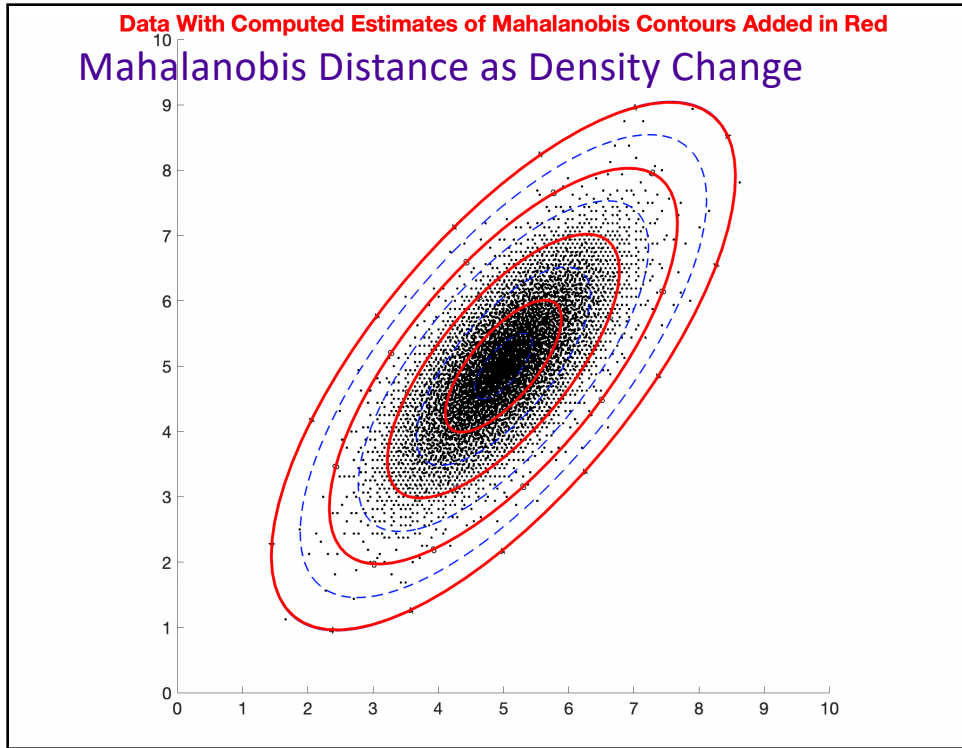
60
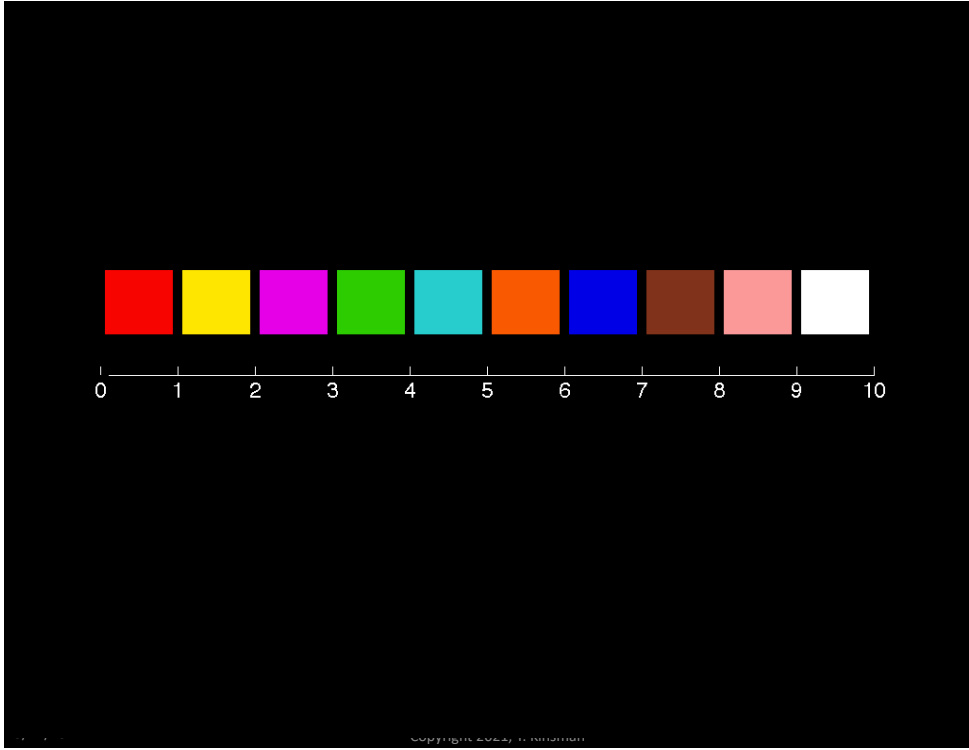
Caution:

- Students and Readers won't know the difference.
They assume the world happens for them.

- Do not kill yourself for RIT.
The extreme measures will not be rewarded…

- Unless you *point out* to them
that they are seeing something not in the book.

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Closing

- No one cannot remember what was on the last slide. Manage attention.
- Have students sketch graphs and relationships.
- There are many plotting routines to use, they are all very similar.
- It is best to get good at one for a start.
Then you can dabble in others.

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