

## Mathematical Simplification Important to Computers

MIT researchers have made an important discovery that could lead to all sorts of amazing technological breakthroughs and, in just a few years, touch every hour of your life. There is now a new way of calculating Fourier Transforms that is up to ten times faster. Fourier transforms are a mathematical trick to simplify how you represent a complicated signal--say the waves of sound made by speaking. They work by reducing the complex wave pattern to a simple and pretty short list of numbers that result in a very good approximation of the original signal. FFTs (Fast Fourier Transforms) are simply a way of making this magic happen in a digital computer. Remember that sound waves, and both picture and video signals, are all handled by processors in your TV, PC, and phone, and that the radio waves that whizz through the air to keep us all connected to the Internet need digital processing too.



That's every compressed sound signal that you listen to as an MP3 or similar format, most every image that you snap with your smartphone or DSLR, every image frame in the video you're watching on your TV streamed over the Net, many images--such as those from an MRI--your doctor uses to diagnose your disease and every burst of radio that connects your cell phone to the nearest tower or your PC to its Wi-Fi router. Calculating FFTs up to ten times faster is a big deal! It means that if you use existing hardware to do the math, it'll be quicker at solving the problem you've set--so you need less compute time to do the task. If you're talking about a portable computer like the one in your smartphone, that means it can spend more time doing other things instead. On the other hand, it also could let you use slower, cheaper computing hardware to do many of the same tasks we use today's hardware to do--meaning the cost could tumble on some everyday objects. There are secondary implications too--the new system could lead to new more efficient image, sound, and video compression techniques, which could impact everything from the amount of data you consume monthly by using your smartphone to the quality of video streamed over your digital TV connection at home.

### Task:

In this activity you will simplify polynomials to create color with the Color Mixer.

## Math Machines Program:

### RGB Color Functions

Activity Files: Poly00X

Load the Polynomial Simplification files and perform the following tasks. Your entries must be completely simplified to be correct.

1. Load **Poly001**. The function for Red is:  $r = -4(2t + 3) - 10(t - 3) + 8t + 82$
- Run the Color Mixer to observe how the color in the Color Box fades from bright red to black.
  - Adding an equal amount of green to red should produce yellow. Copy the expression  $-4*(2*t + 3) - 10*(t - 3) + 8*t + 82$  to the window for green and run the program. You should observe that the Color Box fades from bright yellow (red at 100%, green at 100%) to black.
  - Replace the expression in the green window with its simplified form and run the program. What do you observe?

g = \_\_\_\_\_

- Replace the expression in the red window with the same simplified form and run the program.
- How does this simplified form agree with the graph in the color box window? Could you have determined the simplified form by the graph alone? Explain.

f. Now replace the expression in the green window with an 'r'. Try it!

g. Name at least two advantages in controlling the Color Box with the simplified form?

2. Load **Poly002**. The function for Red is:  $r = t(1-t) + 2t + 100 - 3t$

- Run the Color Mixer to observe how the color in the Color Box fades from bright red to black.
- Adding an equal amount of green & blue to red should produce white. Copy the expression  $t*(1-t) + 2*t + 100 - 3*t$  to the window for green and blue and run the program. You should observe that the Color Box fades from white (red at 100%, green at 100%, blue at 100%) to black.
- Replace the expressions in all windows with the simplified version and run the program. What do you observe?

g = \_\_\_\_\_

b = \_\_\_\_\_

- Replace the expression in the green & blue windows with an 'r' and verify that the Color Box still fades from white to black in the same way.

3. Load **Poly003**. The function for Red is:  $5(8-3t)-10(t-2)^2 + \frac{t^2}{20}(7t+100)$

- Run the Color Mixer to observe how the color in the Color Box changes from black to bright red.
- Adding an equal amount of blue to red should produce purple. Copy the expression  $5*(8-3*t)-10*(t-2)^2 + (1/20)*t^2*(7*t+100)$  for red into the window for blue and run the program to verify that the color changes from black to bright purple (red at 100%, blue at 100%).
- Replace the expression in the red window with the simplified form and the expression in the blue window with 'r' and verify that the Color Box still changes from black to bright purple in the same way.

r = \_\_\_\_\_

b = \_\_\_\_\_

4. Load **Poly004**. The function for Red is:  $(t-5)^2 - (t+3)^2 - 9(t-10) - 6$

- Run the Color Mixer to observe how the color in the Color Box changes from black to bright red.
- Add green to make the color fade from bright orange to black. The RGB values for Orange are Red = 255, Green = 165 so bright orange would be (red at 100%, Green at 165/255\*100%)  
Copy the appropriate expression to the window for green and run the program to verify that the color changes from bright orange to black.
- Replace the expression in the red and green windows with the simplified forms and verify that the Color Box still changes from bright orange to black in the same way.

r = \_\_\_\_\_

g = \_\_\_\_\_

b = \_\_\_\_\_

5. Load **Poly005**. The function for Red is:  $100 - (3t+5)^2(2t-1) + 18t^3 - 25 + 51t^2$

- Run the Color Mixer to observe how the color in the Color Box changes from bright red to black.
- Add green and blue to make the color fade from pink to black. The RGB values for Pink are Red = 255, Green = 192, Blue = 203.
- Replace the expression in the red, green and blue windows with the simplified forms and verify that the Color Box still changes from bright pink to black in the same way

r = \_\_\_\_\_

g = \_\_\_\_\_

b = \_\_\_\_\_

6. Load **Poly006**. The function for Blue is:  $45 + t(t^2 + 2t + 3) - 5(2t^2 - t - 9)$
- Run the Color Mixer to observe how the color in the Color Box changes with various intensities of blue.
  - Add red and green to make the color powder blue. The RGB values for powder blue are Red = 176, Green = 224, Blue = 230.
  - Replace the expressions in the red, green and blue windows with the simplified forms and verify that the Color Box still changes in the same way

r = \_\_\_\_\_

g = \_\_\_\_\_

b = \_\_\_\_\_

## Color Time

## Polynomial Simplification

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  - Adding an equal amount of green to red should produce yellow. Copy the expression  $-4*(2*t+3) - 10*(t-3) + 8*t + 82$  to the window for green and run the program. You should observe that the Color Box fades from bright yellow (red at 100%, green at 100%) to black.
  - Replace the expression in the green window with its simplified form and run the program. What do you observe?

$$g = 100 - 10*t$$

The graphs in both the red and green windows are exactly the same. The color fades from bright yellow to black in the same time.

- Replace the expression in the red window with the same simplified form and run the program again.
- How does this simplified form agree with the graph in the color box window? Could you have determined the simplified form by the graph alone? Explain.

The simplified form is a linear expression. The graphs of  $r = 100 - 10*t$  &  $g = 100 - 10*t$  are linear functions that contain points (0,100) and (10,0)

$$m = \frac{0-100}{10-0} = \frac{-100}{10} = -10 \quad r-0 = -10(t-10) \quad \Rightarrow \quad r = -10t + 100$$

- Now replace the expression in the green window with an 'r'. Try it!
- Name at least two advantages in controlling the Color Box with the simplified form?

- Saves computer calculation time (see Introduction to this activity)
- Simpler to read/understand in programming

2. Load **Poly002**. The function for Red is:  $r = t(1-t) + 2t + 100 - 3t$

- Run the Color Mixer to observe how the color in the Color Box fades from bright red to black.
- Adding an equal amount of green & blue to red should produce white. Copy the expression  $t*(1-t) + 2*t + 100 - 3*t$  to the window for green and blue and run the program. You should observe that the Color Box fades from white (red at 100%, green at 100%, blue at 100%) to black.
- Replace the expressions in all windows with the simplified version and run the program. What do you observe?

$$r = 100 - t^2$$

$$g = 100 - t^2$$

$$b = 100 - t^2$$

- Replace the expression in the green & blue windows with an 'r' and verify that the Color Box still fades from white to black in the same way.

3. Load **Poly003**. The function for Red is:  $5(8-3t)-10(t-2)^2 + \frac{t^2}{20}(7t+100)$

- Run the Color Mixer to observe how the color in the Color Box changes from black to bright red.
- Adding an equal amount of blue to red should produce purple. Copy the expression  $5*(8-3*t)-10*(t-2)^2 + (1/20)*t^2*(7*t+100)$  for red into the window for blue and run the program to verify that the color changes from black to bright purple (red at 100%, blue at 100%).
- Replace the expression in the red window with the simplified form and the expression in the blue window with 'r' and verify that the Color Box still changes from black to bright purple in the same way.

$$r = (7/20)*t^3 - 5*t^2 + 25*t$$

$$b = r$$

4. Load **Poly004**. The function for Red is:  $(t-5)^2 - (t+3)^2 - 9(t-10) - 6$

- Run the Color Mixer to observe how the color in the Color Box changes from black to bright red.
- Add green to make the color fade from bright orange to black. The RGB values for Orange are Red = 255, Green = 165 so bright orange would be (red at 100%, Green at 165/255\*100%) Copy the appropriate expression to the window for green and run the program to verify that the color changes from bright orange to black.

$$r = (t-5)^2 - (t+3)^2 - 9*(t-10) - 6$$

$$g = (165/255)*r$$

- Replace the expression in the red and green windows with the simplified forms and verify that the Color Box still changes from bright orange to black in the same way.

$$r = 100 - 25*t$$

$$g = (165/255)*r$$

5. Load **Poly005**. The function for Red is:  $100 - (3t+5)^2(2t-1) + 18t^3 - 25 + 51t^2$

- Run the Color Mixer to observe how the color in the Color Box changes from bright red to black.
- Add green and blue to make the color fade from pink to black. The RGB values for Pink are Red = 255, Green = 192, Blue = 203.
- Replace the expression in the red, green and blue windows with the simplified forms and verify that the Color Box still changes from bright pink to black in the same way

$$r = 100 - 20*t$$

$$g = (192/255)*r$$

$$b = (203/255)*r$$

6. Load **Poly006**. The function for Blue is:  $45 + t(t^2 + 2t + 3) - 5(2t^2 - t - 9)$
- Run the Color Mixer to observe how the color in the Color Box changes with various intensities of blue.
  - Add red and green to make the color powder blue. The RGB values for powder blue are Red = 176, Green = 224, Blue = 230.
  - Replace the expressions in the red, green and blue windows with the simplified forms and verify that the Color Box still changes in the same way

$$r = (176/230)*b$$

$$g = (224/230)*b$$

$$b = t^3 - 8*t^2 + 8*t + 90$$