

A Drawing Program... but not for Drawing.

Introduction and Objective

Throughout high school, one important thing I learned was what to do when I get stuck or confused: Youtube. This one platform alone consists of several content creators, providing educational material for free, for everyone. Channels such as *Khan Academy*^[1], *The Organic Chemistry Tutor*^[2], and *Patrick JMT*^[3] just to name a few, helped me through my STEM courses. As someone who is very interested in teaching and education, the people running these channels became role models I look up to, and have inspired me to start two educational Youtube channels of my own.^{[4][5]} Using a Medium Wacom drawing tablet, I made videos on materials covered in math and physics competitions. Despite trying out different options, I have never found a suitable drawing software that fits my needs.

Instead of aimlessly trying out different programs, we attempt to systematically determine the ideal "whiteboard program" the main stakeholder, me, should use to make effective educational videos. The program should:

- Allow me to seamlessly write and narrate, with minimal interruptions.
- Create and maintain consistencies in the branding. I want to use the same program for different types of videos.

Here, a whiteboard program is defined as any computer application compatible with the Wacom drawing tablet such that the user can freely write and draw on the digital screen with a digital pen.

Metrics and Criteria

The following metrics are listed alongside their corresponding criteria, listed below from most important to least important.

Shortcuts: How many of the following features can be mapped to a keyboard shortcut?

Criteria: I want the ability to change preferences and continue writing at the same time., allowing me to continue explaining and prevent interruptions. I prefer programs with more keyboard shortcuts for the more important features characterized by the following:

Awesome	Good	Bad
Every functionality can be binded to a shortcut.	The bare basics: changing pen size, swap between pen/eraser.	Offers very little keyboard shortcuts, cannot easily switch between pen, eraser, and change pen size.

Straight Lines: In some drawing programs, there is an option to draw straight lines.

Criteria: I prefer programs which offer the ability to draw these lines, as I am not good at free hand drawing straight lines. It also makes the overall work look more professional.

Multimedia Support: Can the program support pdf files?

- Research has shown that using multimedia tools in teaching can increase effectiveness.^[6] Almost any multimedia file can be turned into a pdf, so I desire a program that offers this functionality.

Price: This measures the cost to use this program in a 2 year period.

Criteria: I want to save money, so I prefer programs that cost the least. However, I am willing to invest money if necessary so this is not a big factor as long as the cost is under a certain amount.

Note: The relationship between all metrics and utility are linear, except for shortcuts, where the utility gap between “Good” and “Awesome” is smaller than the gap between “Bad” and “Good.”

Constraints

- Must Support Images:** I should be able to add in external images in either .PNG, .JPG, or .GIF format. This is vital since a large part of drawing digitally is adding annotations to an existing diagram. These are the image format Windows Snipping Tool automatically exports to, the tool I already use to clip important diagrams.
- Should be less expensive than \$100/year:** This figure was picked as it was around the price of my Wacom drawing tablet. I want to put my money to good use, and if the program costs more than my tablet, it may be better to invest in a better tablet instead. If it costs money, it needs a free trial as I do not want to spend money to test software I might not even choose at the end.
- Should have an Infinite Canvas:** The whiteboard program should have an infinite page option, such that it will be impossible to run out of space. Some programs I used in the past did not have this feature and I often found myself running out of space,^[7] forcing me to cram a lot of information within the page, and wasting time which can cause loss of interest.^[8]

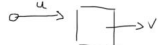
Options

I originally determined the options by reaching out to friends who are more experienced with using drawing tablets for their recommendations. These ranged from note-taking programs to ones used by professional artists. I then found alternatives using the website *AlternativeTo*, a crowdsourced site for recommended software. The ones that met constraints were selected:

<p>Microsoft OneNote^[9]</p>	
-----------------------------------------------	--

Leonardo^[10]

Consider collision between water and skateboard



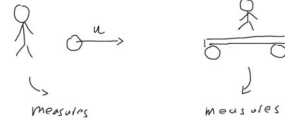
$$\Delta p_{\text{water}} = -dm(u-v)$$

$$\Delta p_{\text{skateboard}} = \Delta p_{\text{water}} = dm(u-v)$$

$$dp = dm(u-v)$$

$$\frac{dp}{dt} = \frac{dm}{dt}(u-v)$$

$$\frac{dm}{dt} = \sigma \left(\frac{u-v}{u} \right)$$



$u = 4 \text{ m/s}$

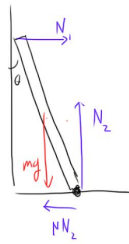
$u' = u - v$

\therefore Mass flow density, thus changes by a factor

$$\frac{u-v}{u}, \text{ so } \frac{dp}{dt} = \frac{\sigma(u-v)^2}{u} = 0.2275 \text{ N}$$

$$\frac{dv}{dt} = \frac{\sigma(u-v)^2}{Mu} = 0.075 \text{ m/s}^2$$

Mischief^[11]



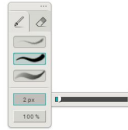
$$N_1 = \mu N_2, \quad N_2 = mg$$

$$N_1(l \cos \theta) = mg \left(\frac{l}{2} \sin \theta \right)$$

$$\mu mg \cos \theta = mg \frac{\sin \theta}{2}$$

$$2\mu = \tan \theta$$

$$\theta_{\text{eq}} = \tan^{-1}(2\mu)$$



Microsoft Whiteboard^[12]

PHY180F Tutorial Questions

1. A particle starts at rest at $t = 0$, but its acceleration is nonzero. The acceleration is 1.0 m/s^2 at $t = 0$ and it changes linearly with time, becoming 3.0 m/s^2 after 4.0 seconds.

Find displacement as a function of time. Find the displacement after 4.0 seconds. Find the average velocity during the first 2.0 seconds of motion.

2. Opposite-coupled pistons cut out 100 meters in about 10 seconds (or less) starting from rest. If you assume they hit top speed in about 3 seconds and keep going at their top speed, find the value of their top speed.

3. A ball starts 1.5 m above the ground, bounces up to a maximum return height (CR) meters above the ground. The entire time from release until the ball reaches the maximum return height, takes 0.25 seconds. Find the average acceleration of the ball while it was in contact with the ground.

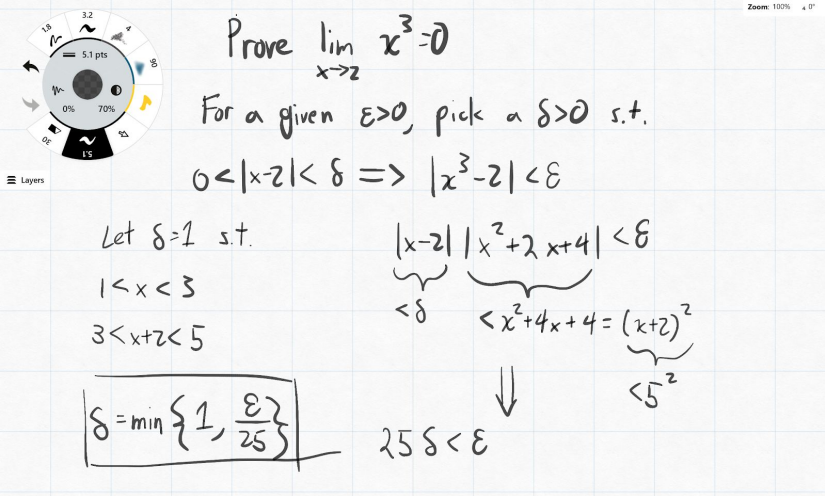
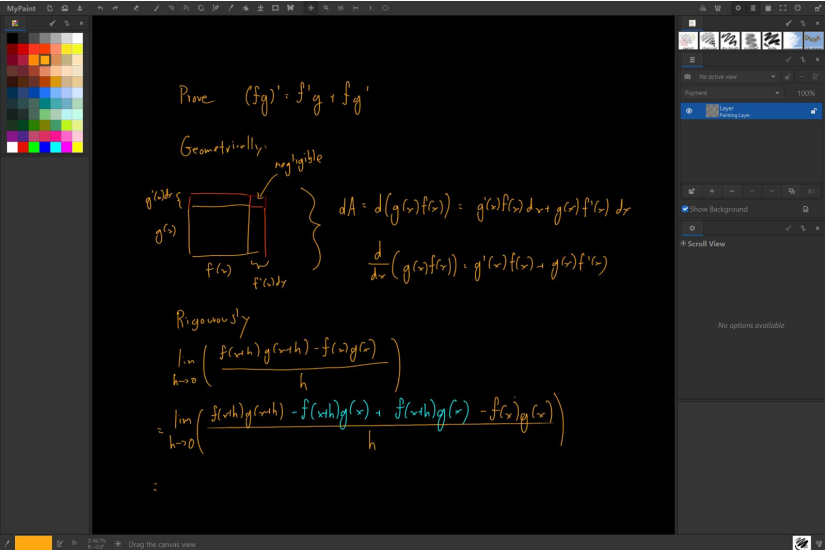
$$h_0 \left[\begin{array}{c} \text{①} \\ \text{②} \\ \text{③} \end{array} \right] \begin{array}{c} \uparrow \\ \downarrow \\ \uparrow \end{array} \begin{array}{c} \text{①} \\ \text{②} \\ \text{③} \end{array} \uparrow h_0$$

$$\text{①} \rightarrow t_1: \sqrt{\frac{2h_0}{g}} \rightarrow V_p = \sqrt{2gh_0}$$

$$\text{②} \rightarrow t_2: \sqrt{g} t_1 \rightarrow V_{f1} = \sqrt{g} V_p$$

$$\text{③} \rightarrow t_2 = T - t_1 - t_3 = T - \sqrt{\frac{2h_0}{g}}(1 + \sqrt{g})$$

$$\bar{a} = \frac{V_1 + V_f}{t_2} = \frac{\sqrt{2gh_0}(1 + \sqrt{g})}{T - \sqrt{\frac{2h_0}{g}}(1 + \sqrt{g})}$$

<p>Concepts^[13]</p>	 <p>Prove $\lim_{x \rightarrow 2} x^3 = 8$</p> <p>For a given $\epsilon > 0$, pick a $\delta > 0$ s.t.</p> $0 < x-2 < \delta \Rightarrow x^3 - 8 < \epsilon$ <p>Let $\delta = 1$ s.t.</p> $1 < x < 3$ $3 < x+2 < 5$ $ x-2 x^2 + 2x + 4 < \epsilon$ $< \delta < x^2 + 4x + 4 = (x+2)^2 < 5^2$ $\delta = \min \left\{ 1, \frac{\epsilon}{25} \right\}$ $25\delta < \epsilon$
<p>MyPaint^[14]</p>	 <p>Prove $(fg)' = f'g + fg'$</p> <p>Geometrically</p> <p>$dA = d(g(x)f(x)) = g(x)dx + f(x)dx$</p> $\frac{d}{dx}(g(x)f(x)) = g'(x)f(x) + g(x)f'(x)$ <p>Rigorously</p> $\lim_{h \rightarrow 0} \left(\frac{f(x+h)g(x+h) - f(x)g(x)}{h} \right)$ $= \lim_{h \rightarrow 0} \left(\frac{f(x+h)g(x+h) - f(x+h)g(x) + f(x+h)g(x) - f(x)g(x)}{h} \right)$

We can list out criteria among these candidates in the table below:

Criteria	Microsoft OneNote	Leonardo	MyPaint	Concepts	Mischief	Microsoft Whiteboard
Shortcuts	Bad	Good	Awesome	Bad	Good	Bad
Vector Tools	Yes	Yes	Yes	None	None	None
Multimedia Support	Yes	No ¹	No	No	No	Yes
Price	Free	\$39 USD	Free	Free	Free	Free

¹ Currently being planned.^[10]

I am currently using the free trial version of Concepts, so I will set it as the benchmark. We can compare the options using a comparison table. For speed, I said that if one of the times is more than double the other, then there is a noticeable difference.

Criteria	Microsoft OneNote	Leonardo	MyPaint	Concepts	Mischief	Microsoft Whiteboard
Shortcuts	0	+	++	0	+	0
Vector Tools	0	0	0	-	-	-
Multimedia Support	0	-	-	-	-	0
Price	0	-	0	0	0	0

Recommendation

The benchmark *Microsoft OneNote* compares well to the alternatives, with no nothing doing better for more than one category. The three top contenders are *Leonardo*, *MyPaint*, and *Mischief*: where all three are better than *OneNote* in the first (most important) criteria: shortcuts. The other two alternatives: *Concepts* and *Microsoft Whiteboard* are not viable as they do not meet any criteria better than *OneNote*.

Despite *MyPaint* being free and having a wider range of shortcuts, I recommend *Leonardo* for the ideal program. Despite the lack of customizability, *Leonardo* provides key bindings to the most important features I use. It only lacks the ability to swap between different colors which although is a useful feature to have, it is not necessary to create a good video. Additionally, even in *MyPaint*, the user can only swap between two colours with keyboard shortcuts so the two programs have the same efficiency when switching between several colors.

While both *Leonardo* and *MyPaint* do not offer pdf import functionalities, this is currently under development for *Leonardo* for the near future. On the other hand, *MyPaint*, a program designed for painting will probably not be looking to implement this feature. It is also quite old with its last major update in 2016, while *Leonardo* is still in its Beta release stage. In the future, I expect it to offer full multimedia support.^{[10][14]} Although it is not free, the \$39 one time purchase is not a huge deal to me.


While *Microsoft OneNote* is also an extremely versatile program, the lack of keyboard shortcuts breaks up the flow of the video. In order to make the best educational videos I can, I should invest in *Leonardo* for long term benefits.

References

- [1] Khan Academy. Retrieved October 02, 2020, from <https://www.youtube.com/user/khanacademy>
- [2] The Organic Chemistry Tutor. Retrieved October 02, 2020, from <https://www.youtube.com/user/TheOrganicChemistryTutor/>
- [3] Patrick JMT. Retrieved October 02, 2020, from <https://www.youtube.com/user/patrickJMT>
- [4] Margin Too Small. Retrieved October 02, 2020, from <https://www.youtube.com/channel/UCMBodNeDr7LxLqQXnvQaLLw>
- [5] Physoly. Retrieved October 02, 2020, from <https://www.youtube.com/channel/UCf0Rgy-gjdwJd-9-BBGJ7cA>
- [6] Meo, S. A., Shahabuddin, S., Al Masri, A. A., Ahmed, S. M., Aqil, M., Anwer, M. A., & Al-Drees, A. M. (2013). Comparison of the impact of powerpoint and chalkboard in undergraduate medical teaching: an evidence based study. *Journal of the College of Physicians and Surgeons--Pakistan : JCPSP*, 23(1), 47–50.
- [7] Xue, Q. (2019, October 26). *Week 6A: Energy II (2/2)*. Youtube. Retrieved October 02, 2020, from <https://www.youtube.com/watch?v=bcy3DP3ELYA>
- [8] Lang, P. (n.d.). *Youtube Average View Duration – The 50% Rule*. Uhuru Network. Retrieved October 02, 2020, from <https://uhurunetwork.com/the-50-rule-for-youtube/>
- [9] OneNote, digital note taking app - Office. (n.d.). Retrieved from <https://www.microsoft.com/en-ca/microsoft-365/onenote/digital-note-taking-app>
- [10] Tening, Hegen. (n.d.). The best drawing & painting app for Windows. Retrieved October 02, 2020, from <https://www.getleonardo.com/>
- [11] Mischief. (n.d.). Retrieved August 4, 2018, from <https://web.archive.org/web/20180804091257/https://www.madewithmischief.com>
- [12] Microsoft Whiteboard, Interactive Online Whiteboard App, IWB. (n.d.). Retrieved October 02, 2020, from <https://www.microsoft.com/en-ca/microsoft-365/microsoft-whiteboard/digital-whiteboard-app>
- [13] TopHatch. (n.d.). Concepts App • Infinite, Flexible Sketching. Retrieved October 02, 2020, from <https://concepts.app/en/>
- [14] MyPaint. (n.d.). Retrieved October 02, 2020, from <http://mypaint.org/>

Source Extracts


[1]



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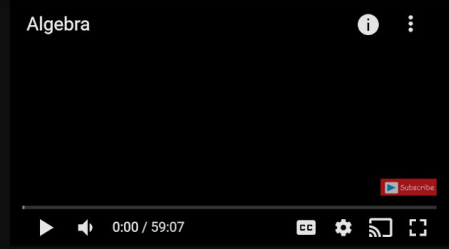
[2]



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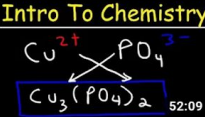
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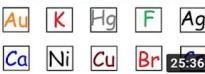
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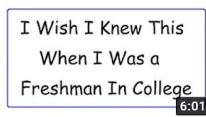
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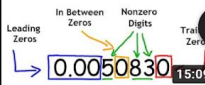
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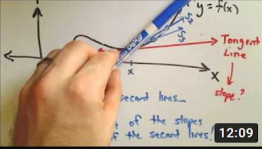
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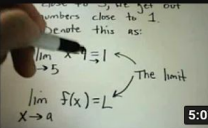


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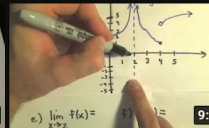


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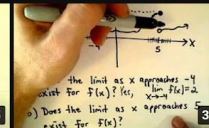


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7 Animated Pythagorean Theorem Proofs In A Minute
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These are the 7 simplest proofs I could animate with Microsoft Powerpoint 2016.


NOTE At 1:06, it should have been (B+A)*2 instead of (B*A)*2. Sorry!

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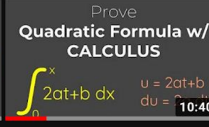
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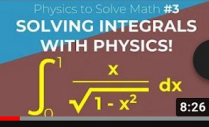
7 Pythagorean Proofs In ONE MINUTE
1:18



Prove Quadratic Formula w/ CALCULUS
 $\int_0^x 2at+b \, dx$
 $u = 2at+b$
 $du = 2a$
10:40



AM-GM Inequality Proof In 3 MINUTES
 $\frac{a+b}{2} > \sqrt{ab}$
2:52



SOLVING INTEGRALS WITH PHYSICS!
 $\int_0^1 \frac{x}{\sqrt{1-x^2}} \, dx$
8:26

7 Animated Pythagorean Theorem Proofs In A Minute
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[6]

Results: Students who attended the class on both PowerPoint and chalkboard obtained significantly higher score in single best MCQ examination compared to those students who attended the same content based lecture on the PowerPoint or chalkboard alone ($p = 0.05$).

[7]

Initial period expired

$P_{avg} = \frac{\Delta E}{\Delta t}$

$h = 5m \quad 2sec \quad P_{avg} = \frac{mgh}{t} = 490 W$

$v = 3m/s \quad 2kg$

$P_{avg} = \frac{mgh}{t} = mgv = (2)(9.8)(3) = 58.8 W$

$= \vec{F} \cdot \vec{v} \rightarrow P_{avg} = \frac{\Delta E}{\Delta t} = \frac{W}{t}$

Week 6A: Energy II (2/2)
Unlisted
2 views · Oct 26, 2019

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[8]

The 50% Rule For YouTube: *Keep your videos short and include your call-to-action before the half-way mark.*

Finding YouTube Average View Duration

We recently analyzed 56,000+ YouTube views across four small yet effective YouTube channels.

We found a significant drop-off in viewer retention around the half-way point of the video. We found this interesting because the channels are each very different from one another. The channels vary in content types and average video length, ranging from pure entertainment to educational and 1 min average videos to 8 min average videos. **Each YouTube average view duration was somewhere around 50-60% of the total video length.**

[9]

OneNote at a glance



Organize

Sort content across notebooks, sections, and pages.



Tag

Highlight can't-miss notes with Important and To-Do tags.



Ink

Draw your thoughts and annotate your notes, using a stylus or your finger.



Mix media

Record audio notes, insert online videos, and add files.



Clip and save

Use the OneNote Web Clipper to save content with a single click.



Share

Share notebooks with coworkers, friends, and family.

[10]

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Paint bucket and magic wand!

Henning Tegen on March 7, 2019

We are very excited to announce **version 0.16.24** of Leonardo! In this release we have added two of our most requested features: a **Paint bucket tool** and a **Magic Wand tool**. We have also spent a lot of time cleaning up the code base and optimized performance.

Can Leonardo import PDF files?

No. However, this is a common request. Hopefully we can add it in the future.

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[11]

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[13]

Infinite, flexible sketching.

Sketch, plan, edit and share all your big ideas.



[14]

Nov 2, 2010

MyPaint 0.9.0

The new major release of MyPaint, version 0.9.0 is here! It has been 9 months since the last major release now, so it was about time. Hopefully the next cycle will be a bit shorter.