
DOOM
ED
EUCLIDE

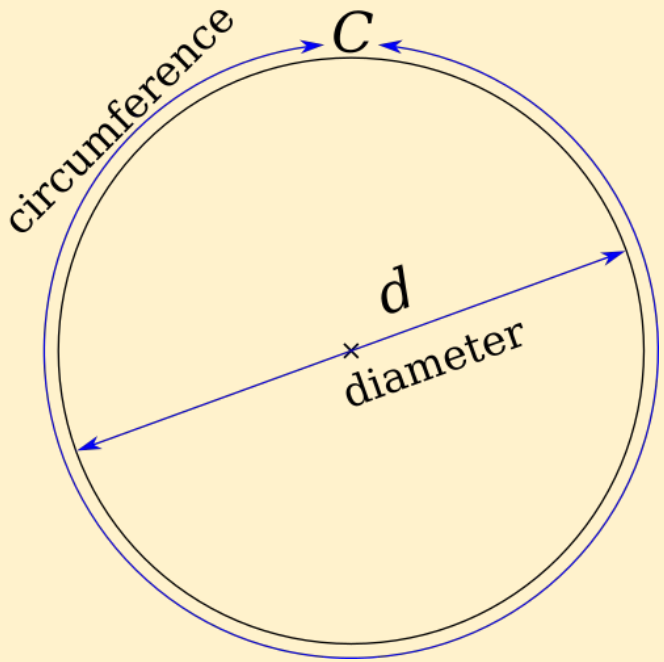
Geometria euclidea

È la geometria basata sugli assiomi di Euclide:

1. Congiungendo due punti qualsiasi si ottiene un segmento di retta;
2. Si può prolungare un segmento oltre i due punti indefinitamente;
3. Dato un punto e una lunghezza, è possibile descrivere un cerchio;
4. Tutti gli angoli retti sono congruenti tra loro;
5. Se una retta che taglia altre due rette determina dallo stesso lato angoli interni la cui somma è minore di due angoli retti, prolungando le due rette, esse si incontreranno dalla parte dove i due angoli hanno somma minore di due retti.

Pi Greco: cos'è?

- Pi Greco (π) è una costante matematica
- Corrisponde al rapporto tra una **circonferenza** e il suo **diametro**
- È nota da migliaia di anni prima della nascita di Cristo.

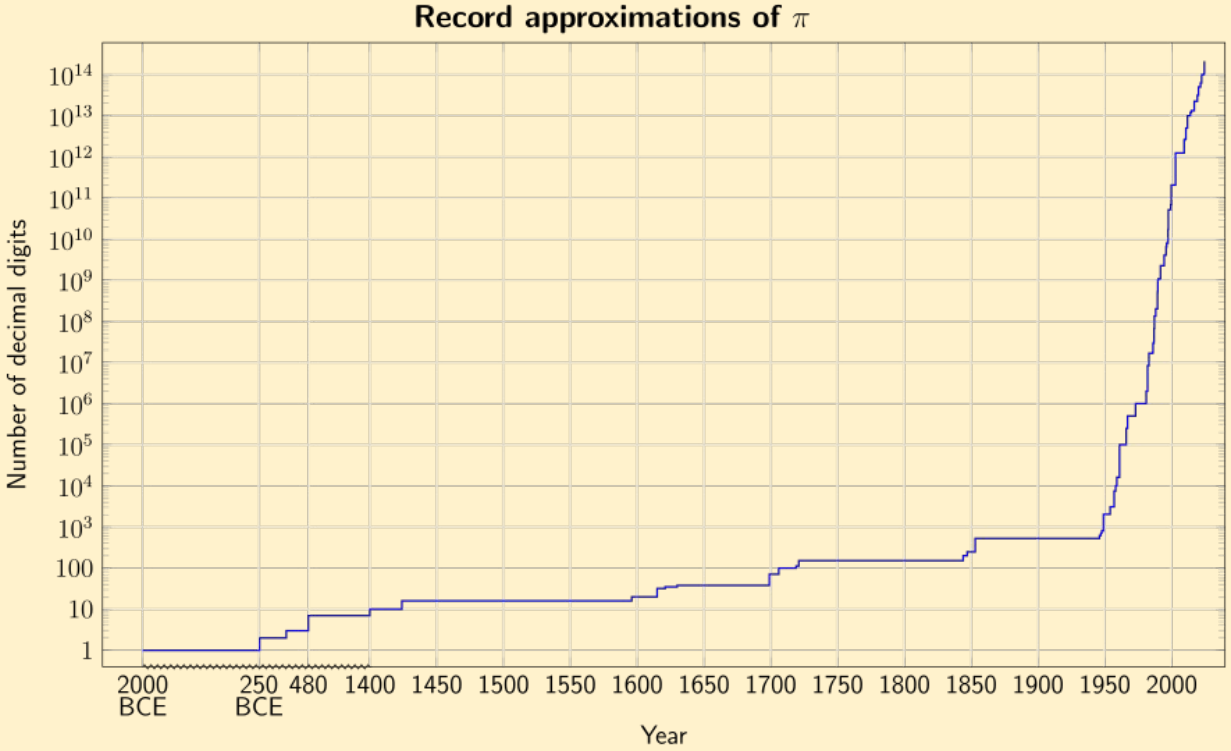


π = 3.14159…

3 e qualcosa

Circumference = ? (Animation) - GeoGebra

Pi Greco negli anni



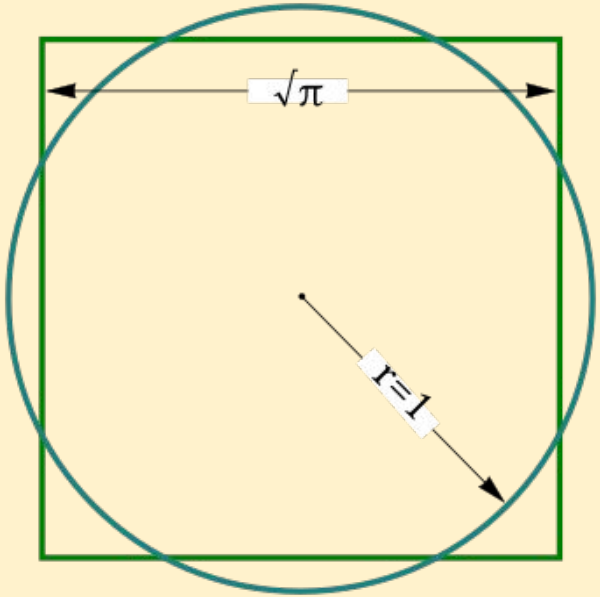
Pi Greco: caratteristiche

- È un numero **irrazionale**

  (non può essere espresso come frazione di interi)

- È un numero **trascendente**

  (In matematica un numero trascendente è un numero irrazionale che non è un numero algebrico, ossia non è la soluzione di nessuna equazione polinomiale di una certa forma)



Pi Greco è irrazionale

Hermite's proof [edit]

Written in 1873, this proof uses the characterization of π as the smallest positive number whose half is a zero of the cosine function and it actually proves that π^2 is irrational.[3][4] As in many proofs of irrationality, it is a proof by contradiction.

Consider the sequences of real functions A_n and U_n for $n \in \mathbb{N}_0$ defined by:

$$A_0(x) = \sin(x), \qquad A_{n+1}(x) = \int_0^x y A_n(y)\,dy$$

$$U_0(x) = \frac{\sin(x)}{x}, \qquad U_{n+1}(x) = -\frac{U_n'(x)}{x}$$

Using induction we can prove that

$$A_n(x) = \frac{x^{2n+1}}{(2n+1)!!} - \frac{x^{2n+3}}{2\times(2n+3)!!} + \frac{x^{2n+5}}{2\times4\times(2n+5)!!} \mp \cdots$$

$$U_n(x) = \frac{1}{(2n+1)!!} - \frac{x^2}{2\times(2n+3)!!} + \frac{x^4}{2\times4\times(2n+5)!!} \mp \cdots$$

and therefore we have:

$$U_n(x) = \frac{A_n(x)}{x^{2n+1}}.$$

So

$$\begin{aligned}\frac{A_{n+1}(x)}{x^{2n+3}} = U_{n+1}(x) &= -\frac{U_n'(x)}{x} = -\frac{1}{x}\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{A_n(x)}{x^{2n+1}}\right)\\ &= -\frac{1}{x}\left(\frac{A_n'(x)\cdot x^{2n+1} - (2n+1)x^{2n}A_n(x)}{x^{2(2n+1)}}\right)\\ &= \frac{(2n+1)A_n(x) - xA_n'(x)}{x^{2n+3}}\end{aligned}$$

which is equivalent to

$$A_{n+1}(x) = (2n+1)A_n(x) - x^2 A_{n-1}(x).$$

Using the definition of the sequence and employing induction we can show that

$$A_n(x) = P_n(x^2)\sin(x) + xQ_n(x^2)\cos(x),$$

where P_n and Q_n are polynomial functions with integer coefficients and the degree of P_n is smaller than or equal to $\lfloor \frac{1}{2}n \rfloor$. In particular, $A_n\left(\frac{1}{2}\pi\right) = P_n\left(\frac{1}{4}\pi^2\right)$.

Hermite also gave a closed expression for the function A_n, namely

$$A_n(x) = \frac{x^{2n+1}}{2^n n!}\int_0^1 (1-z^2)^n \cos(xz)\,\mathrm{d}z.$$

He did not justify this assertion, but it can be proved easily. First of all, this assertion is equivalent to

$$\frac{1}{2^n n!}\int_0^1 (1-z^2)^n \cos(xz)\,\mathrm{d}z = \frac{A_n(x)}{x^{2n+1}} = U_n(x).$$

Proceeding by induction, take $n = 0$.

$$\int_0^1 \cos(xz)\,\mathrm{d}z = \frac{\sin(x)}{x} = U_0(x)$$

and, for the inductive step, consider any natural number n. If

$$\frac{1}{2^n n!}\int_0^1 (1-z^2)^n \cos(xz)\,\mathrm{d}z = U_n(x),$$

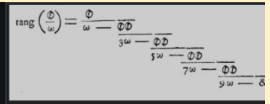
then, using integration by parts and Leibniz's rule, one gets

$$\begin{aligned}&\frac{1}{2^{n+1}(n+1)!}\int_0^1 (1-z^2)^{n+1}\cos(xz)\,\mathrm{d}z\\ &\quad= \frac{1}{2^{n+1}(n+1)!}\left(\overbrace{(1-z^2)^{n+1}\frac{\sin(xz)}{x}\Big|_{z=0}^{z=1}}^{=0} + \int_0^1 2(n+1)(1-z^2)^n z\frac{\sin(xz)}{x}\,\mathrm{d}z\right)\\ &\quad= \frac{1}{x}\cdot\frac{1}{2^n n!}\int_0^1 (1-z^2)^n z\sin(xz)\,\mathrm{d}z\\ &\quad= -\frac{1}{x}\cdot\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2^n n!}\int_0^1 (1-z^2)^n\cos(xz)\,\mathrm{d}z\right)\\ &\quad= -\frac{U_n'(x)}{x}\\ &\quad= U_{n+1}(x).\end{aligned}$$

If $\frac{1}{4}\pi^2 = p/q$, with p and q in $\mathbb{N}$, then, since the coefficients of P_n are integers and its degree is smaller than or equal to $\lfloor \frac{1}{2}n \rfloor$, $q^{\lfloor n/2 \rfloor} P_n\left(\frac{1}{4}\pi^2\right)$ is some integer N. In other words,

$$N = q^{\lfloor n/2 \rfloor} A_n\left(\tfrac{1}{2}\pi\right) = q^{\lfloor n/2 \rfloor}\frac{1}{2^n n!}\left(\frac{p}{q}\right)^{n+\frac{1}{2}}\int_0^1 (1-z^2)^n\cos\left(\tfrac{1}{2}\pi z\right)\mathrm{d}z.$$

But this number is clearly greater than 0. On the other hand, the limit of this quantity as n goes to infinity is zero, and so, if n is large



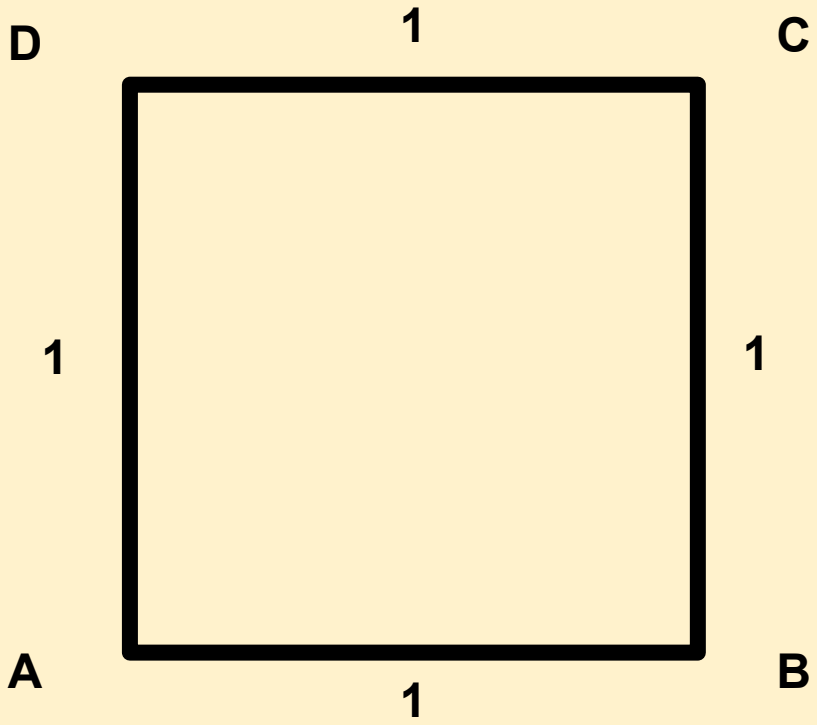
Scan of formula on page 288 of Lambert's "Mémoires sur quelques propriétés remarquables des quantités transcendantes, circulaires et logarithmiques", Mémoires de l'Académie royale des sciences de Berlin (1768), 265–322

Pi Greco: a cosa serve?

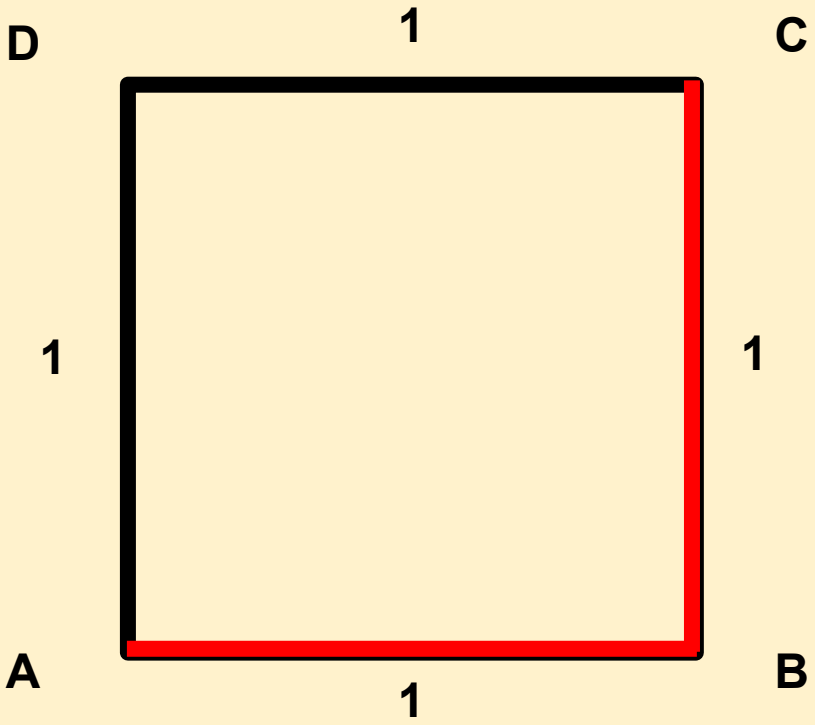
- Essendo una costante relativa alla circonferenza, è fondamentale in tutti i campi in cui si vuole comprendere lo spazio, come la geometria, l'analisi matematica, ma anche l'elettronica, la fisica, la statistica…

- È un'unità di misura, i **radianti**

Esempio

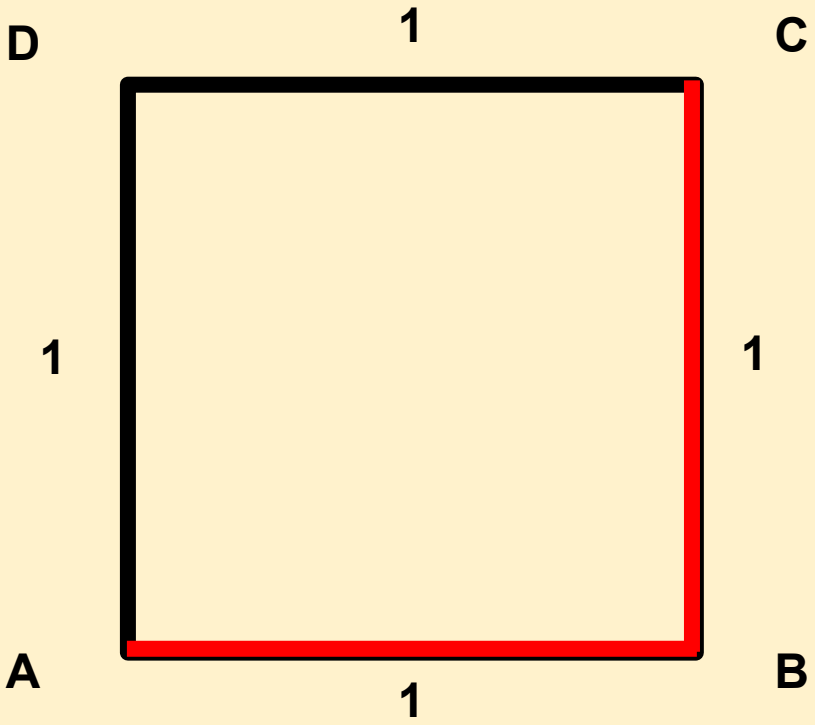


Esempio



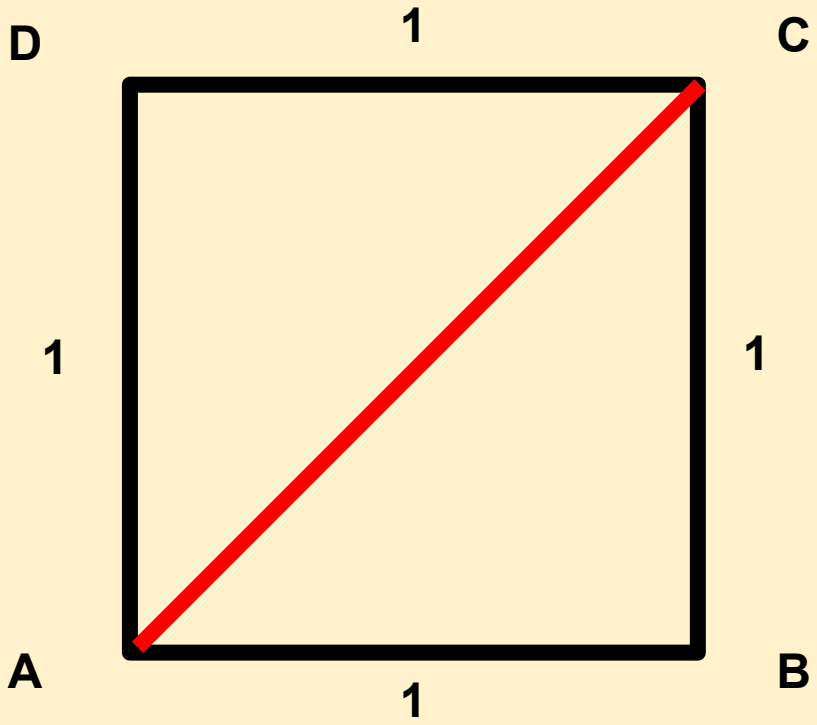
- AB-BC =

Esempio



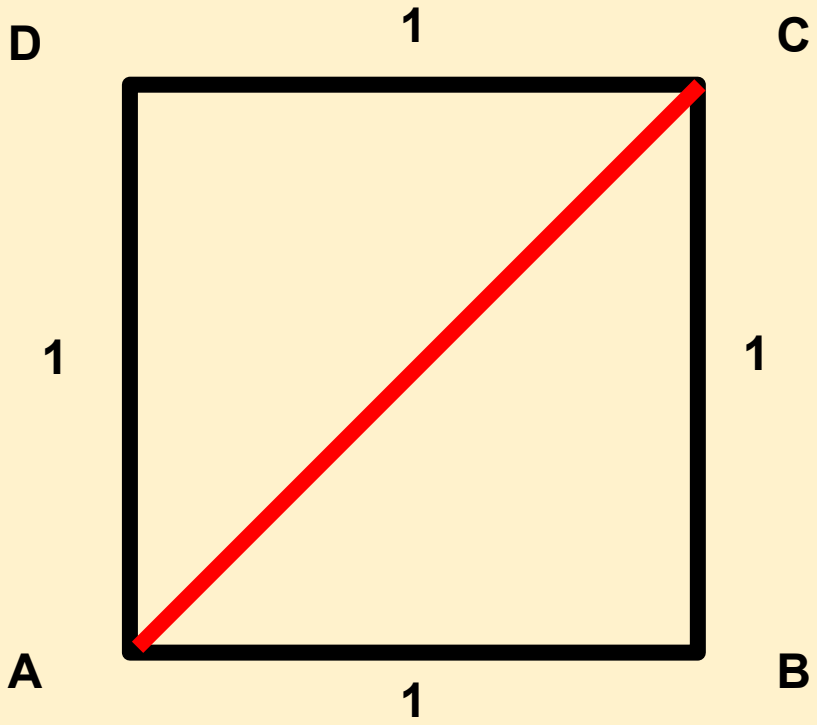
- AB-BC = 2

Esempio



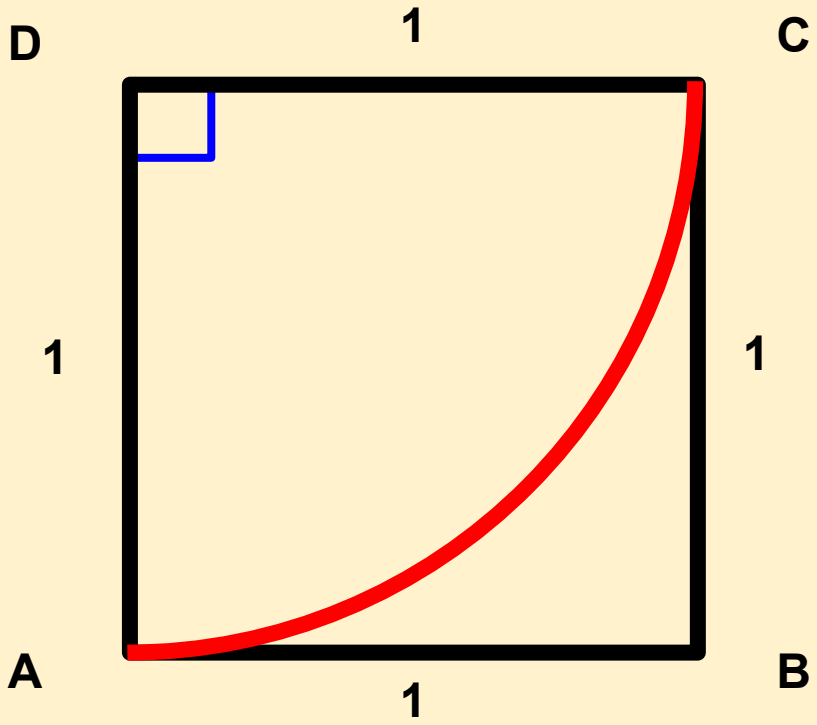
- AB-BC = 2
- AC =

Esempio



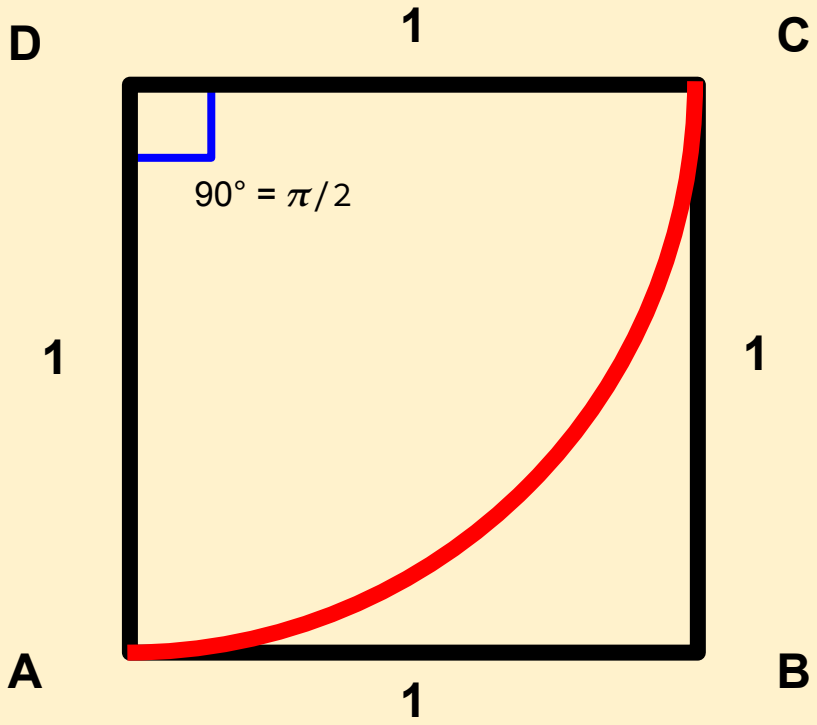
- AB-BC = 2
- AC = $\sqrt{1^2+1^2} = \sqrt{2} \approx 1,4$

Esempio



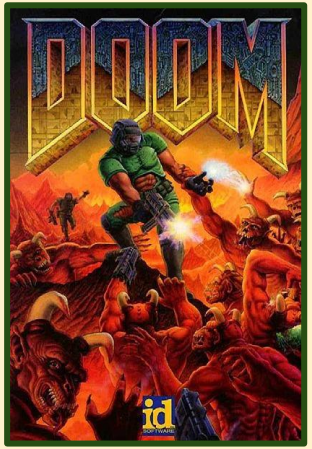
- AB-BC = 2
- AC = $\sqrt{1^2+1^2} = \sqrt{2} \approx 1,4$
- AC (arco) =

Esempio



- AB-BC = 2
- AC (retta) = $\sqrt{1^2+1^2 =}$ = $\sqrt{2} \approx 1{,}4$
- AC (arco) = $\pi/2 \approx 1{,}6$

Doom (1993)

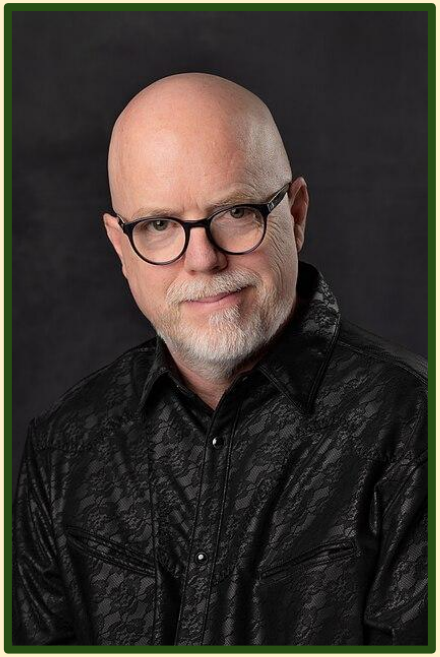


- È un gioco rilasciato nel 1993 da **id software**
- È stato uno dei primi **sparatutto in prima persona**
- È diventato un **fenomeno mondiale**
- L’engine è **open source**

id Software Shreveport, Louisiana, 1991

John Carmack

John Romero



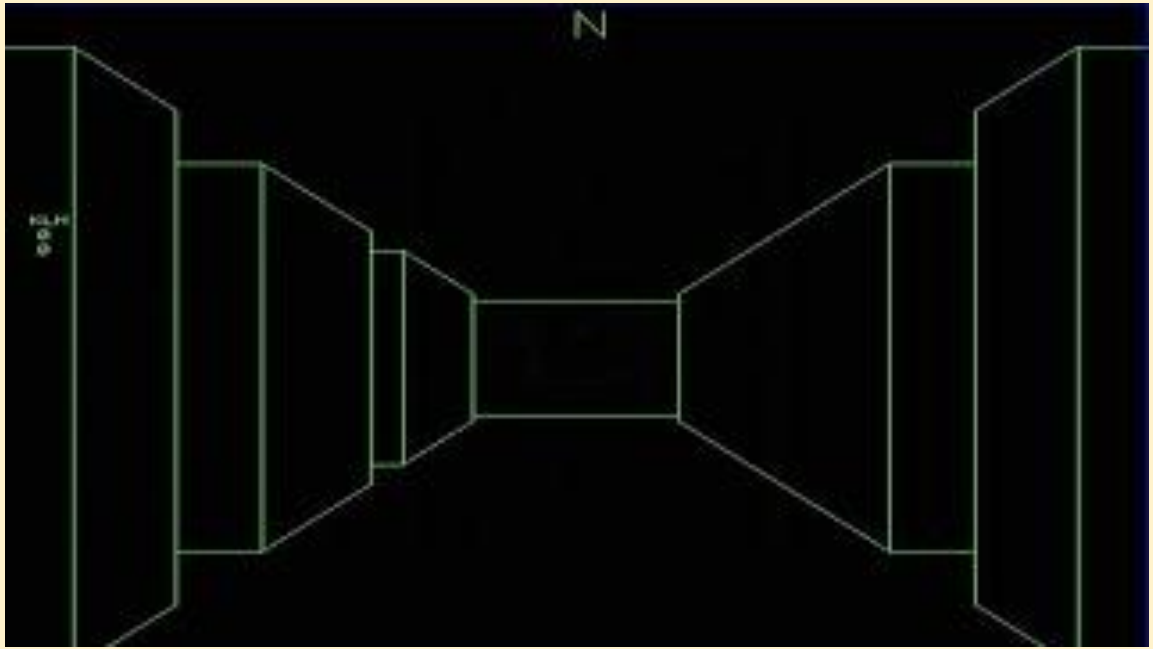
Tom Hall

Adrian Carmack

FPS negli anni

- **Maze War (1974)**

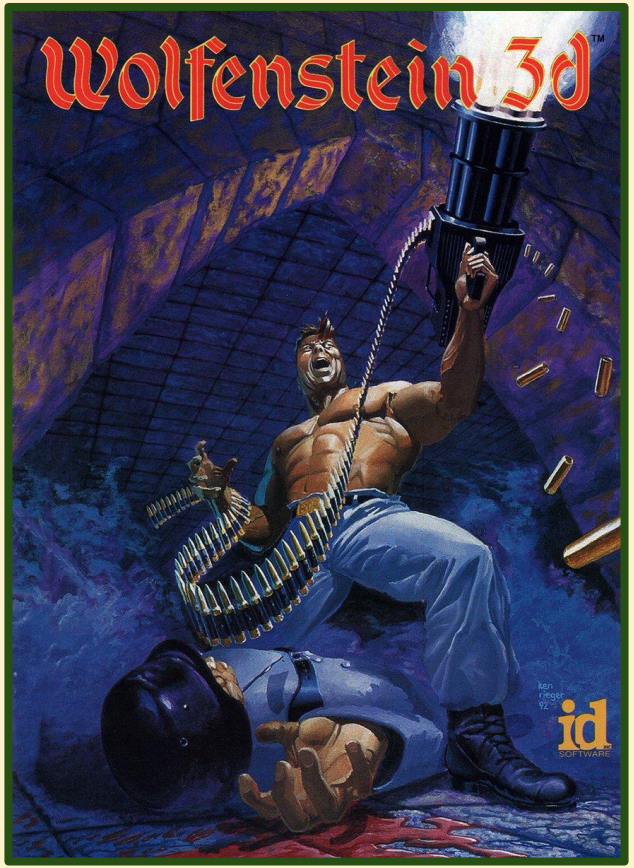
Creato da 4 studenti del liceo in America



FPS negli anni

- **Wolfenstein 3D (1992)**

Primo FPS sviluppato dalla id Software



FPS negli anni

- Doom (2016), Doom Eternal (2020) e Doom The Dark Ages (2025)

FPS negli anni

27 anni di videogiochi

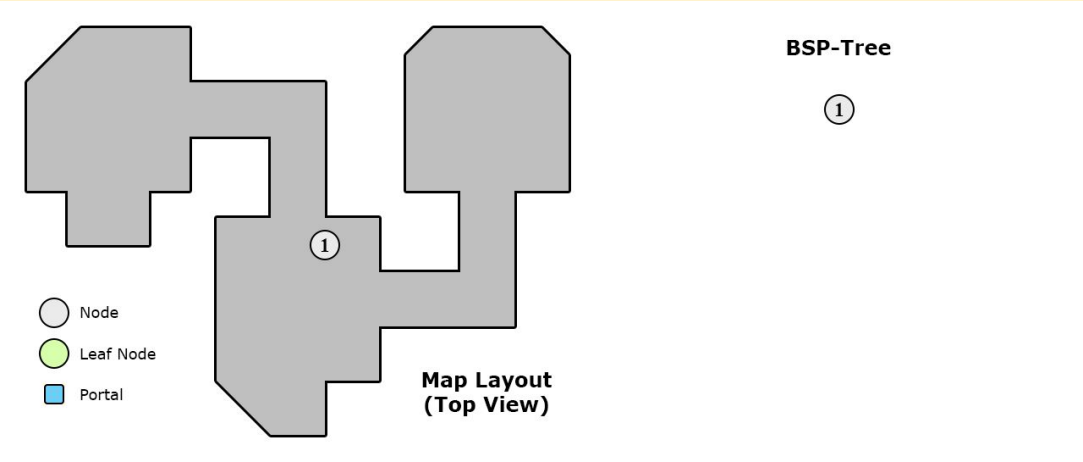
Spazi 3D (circa)

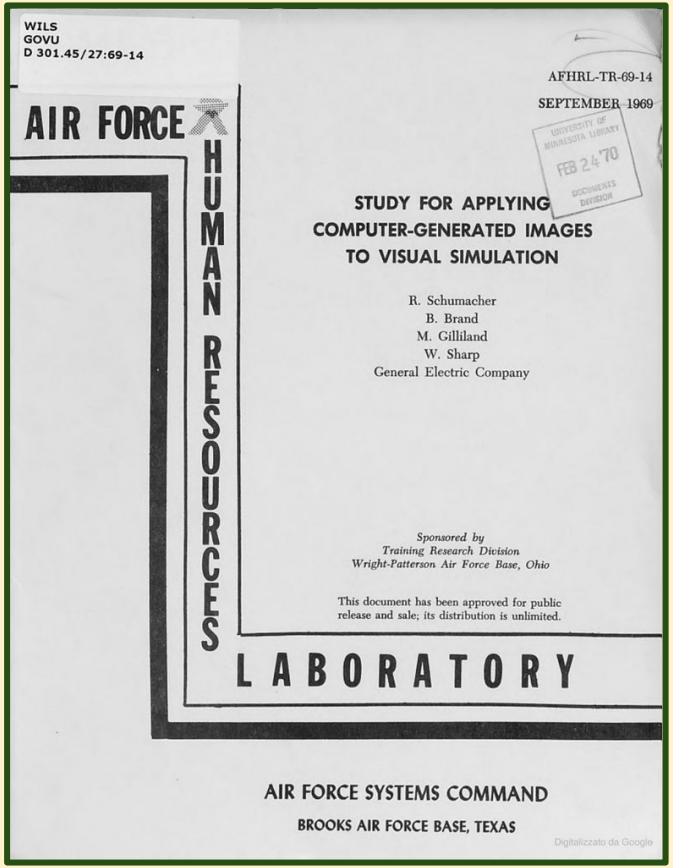
- **Doom** è 2.5D

- Non si può guardare in alto

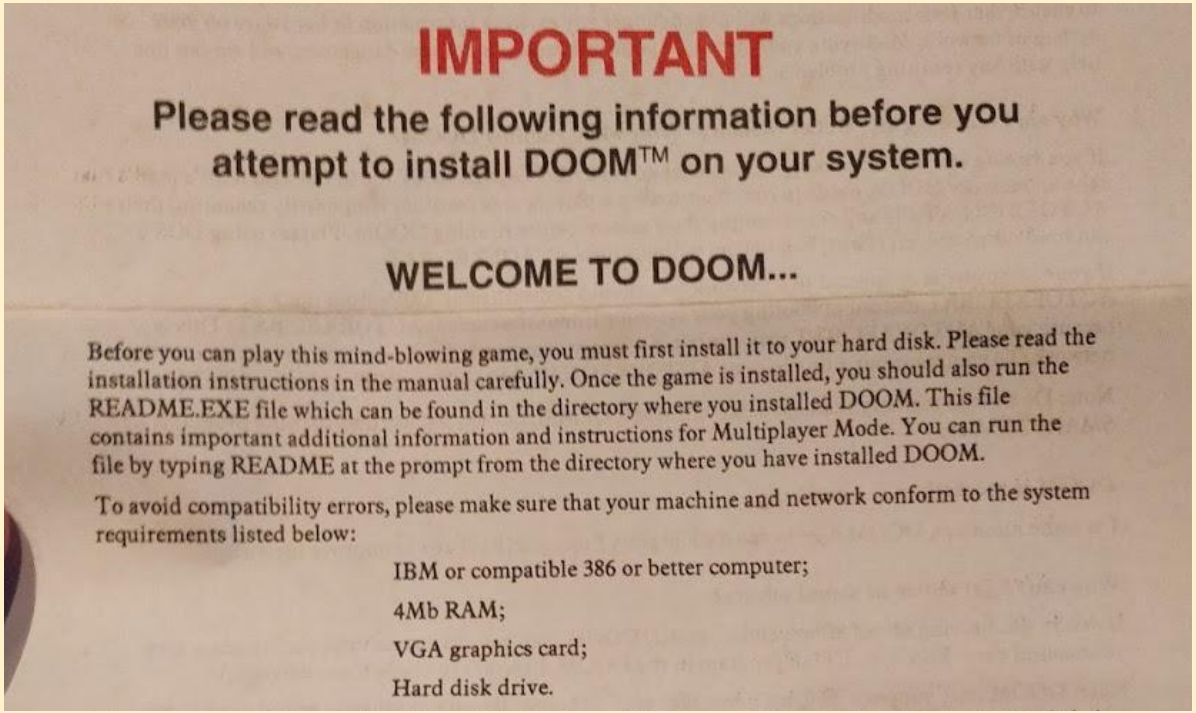
Ottimizzazione

- **BSP:** Binary Space Partition





Facile da girare



IMPORTANT

Please read the following information before you attempt to install DOOM™ on your system.

WELCOME TO DOOM...

Before you can play this mind-blowing game, you must first install it to your hard disk. Please read the installation instructions in the manual carefully. Once the game is installed, you should also run the README.EXE file which can be found in the directory where you installed DOOM. This file contains important additional information and instructions for Multiplayer Mode. You can run the file by typing README at the prompt from the directory where you have installed DOOM.

To avoid compatibility errors, please make sure that your machine and network conform to the system requirements listed below:

IBM or compatible 386 or better computer;

4Mb RAM;

VGA graphics card;

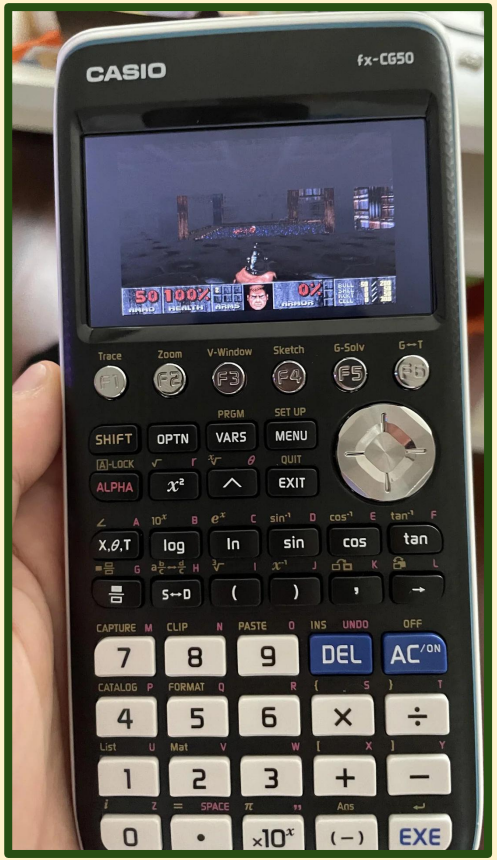
Hard disk drive.

Facile da girare

My office phone runs doom : r/itrunsdoom

r/itrunsdoom on Reddit: Does Chandler's laptop run DOOM? So I found out which laptop Chandler had, fixed it and installed Doom on it.

Scientists get Doom running on chips powered by 200,000 human neurons, and those clever little cells are playing it too



CPU, GPU E FPU

- All’epoca di Doom le **CPU** non erano dotate di **FPU** (Floating Point Unit), e le **GPU** per consumatori non esistevano. Niente *3D acceleration*.

- Per evitare di calcolare gli angoli mentre gira il gioco, John Carmack usò delle *look-up tables*.

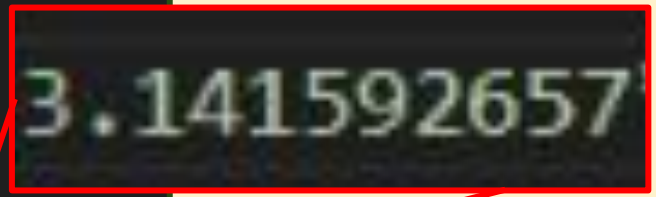
Cosa c'entra pi in Doom?

- **Pi greco** è usato per tutti i calcoli relativi agli angoli (trigonometria), perciò lo troviamo proprio nelle funzioni che generano le *look-up tables*

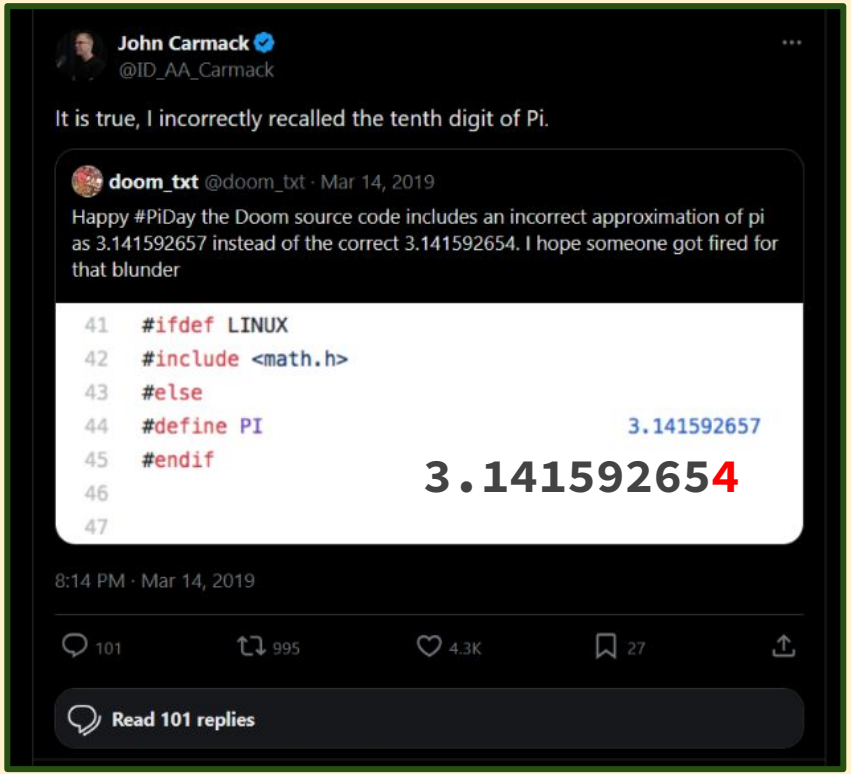
- Sono un po' come un formulario in matematica (o qualsiasi materia)

Cosa c'entra pi in Doom?

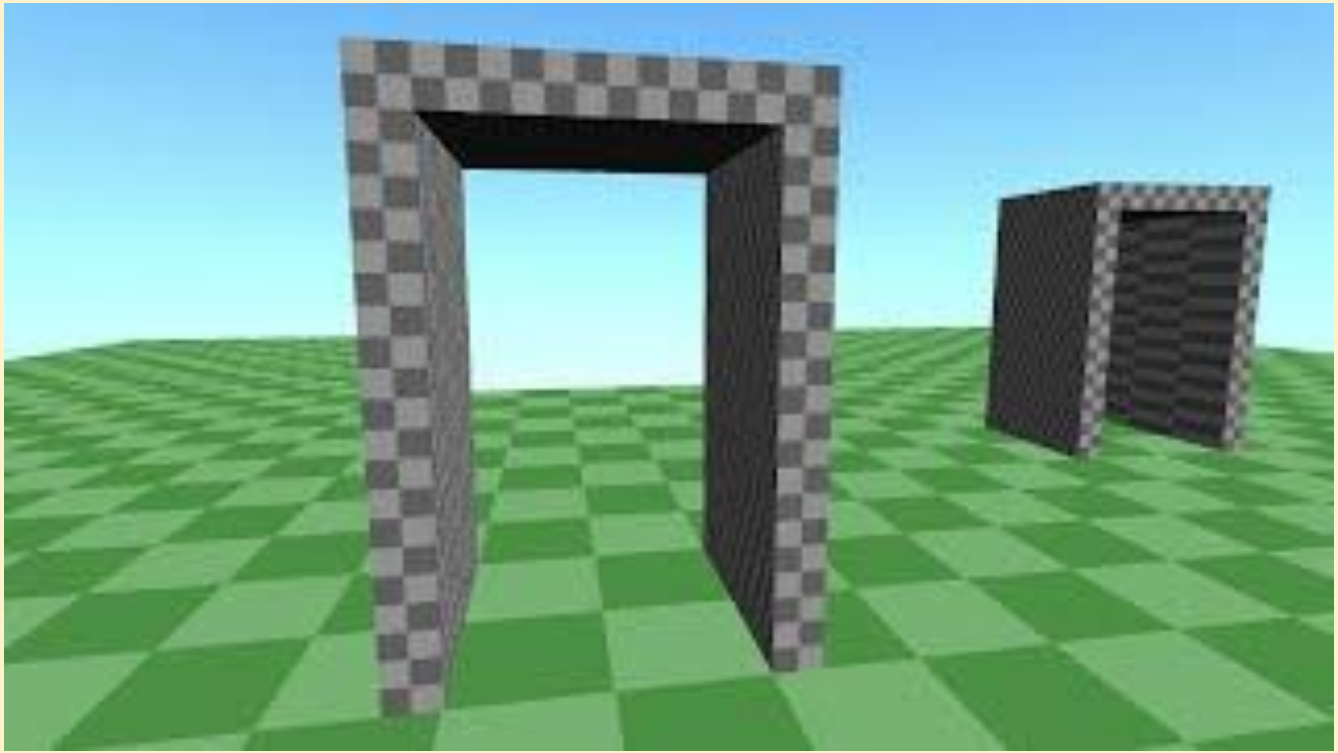
```
//
// R_InitPointToAngle
//
void R_InitPointToAngle (void)
{
    // UNUSED - now getting from tables.c

    int i;
    long    t;
    float   f;

  slope (tangent) to angle lookup

    for (i=0 ; i<=SLOPERANGE ; i++)
    {
    f = atan( (float)i/SLOPERANGE )/(3.141592657*2);
    t = 0xffffffff*f;
    tantoangle[i] = t;
    }
}
```



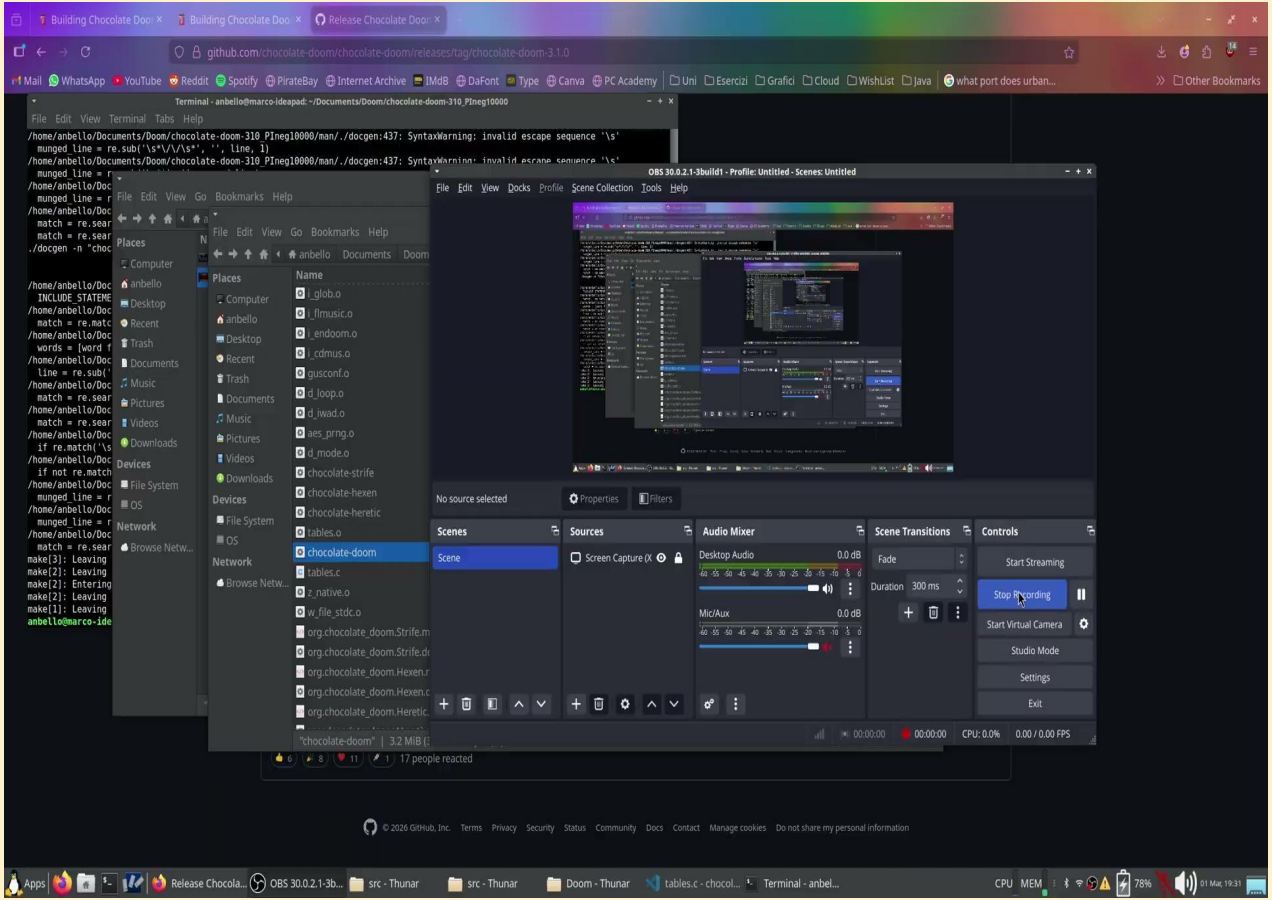
Cosa c'entra pi in Doom?



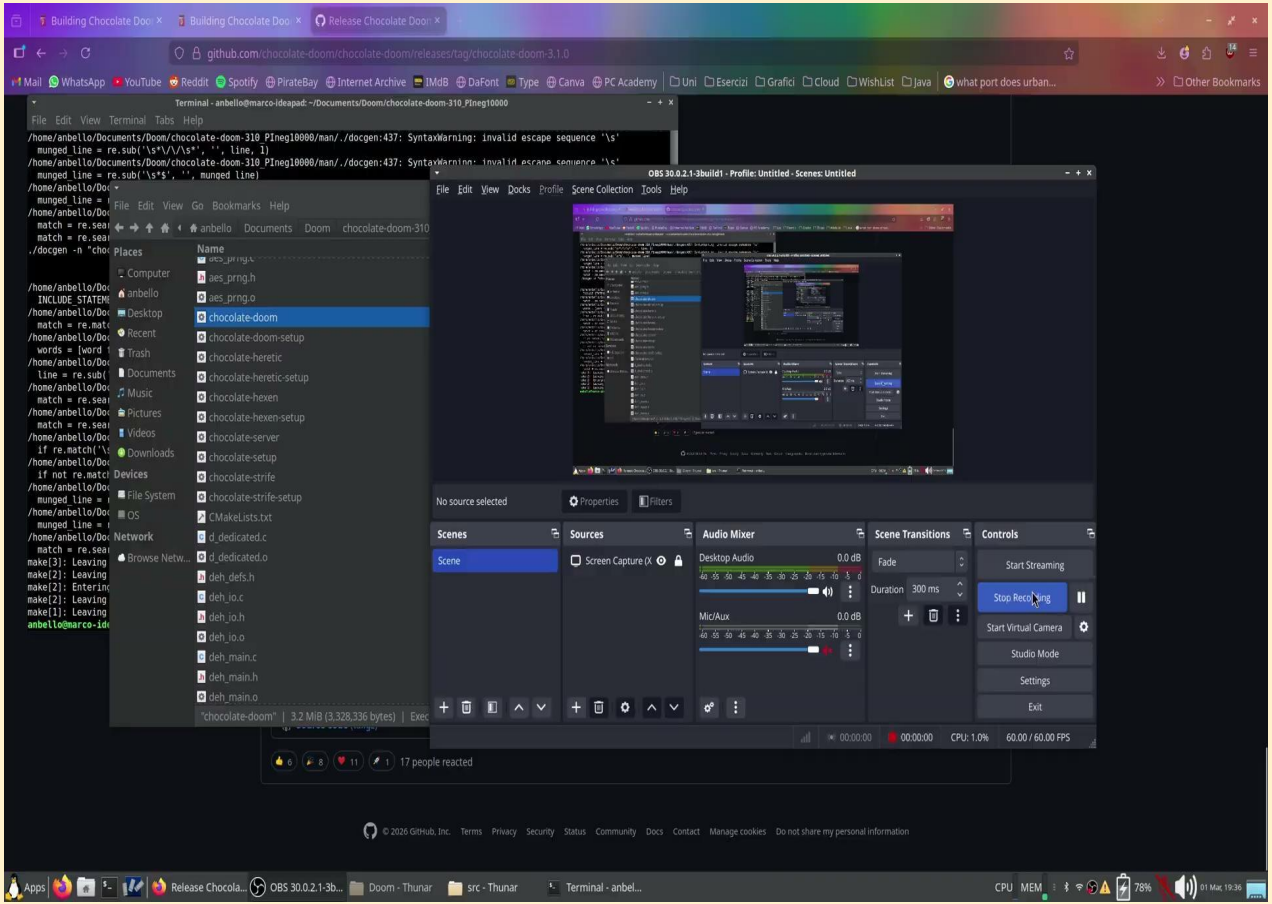
Spazi non euclidei



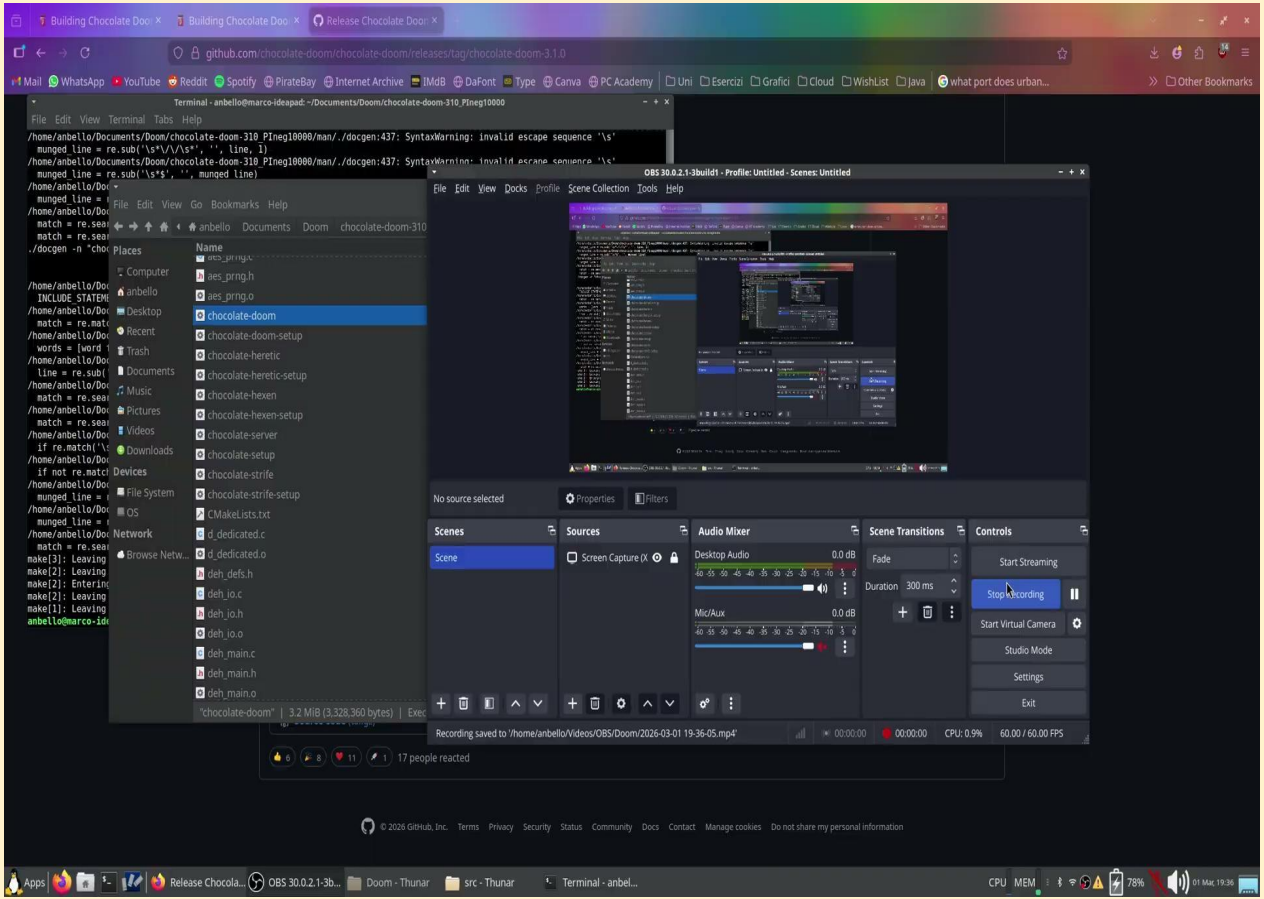
DOOM normale



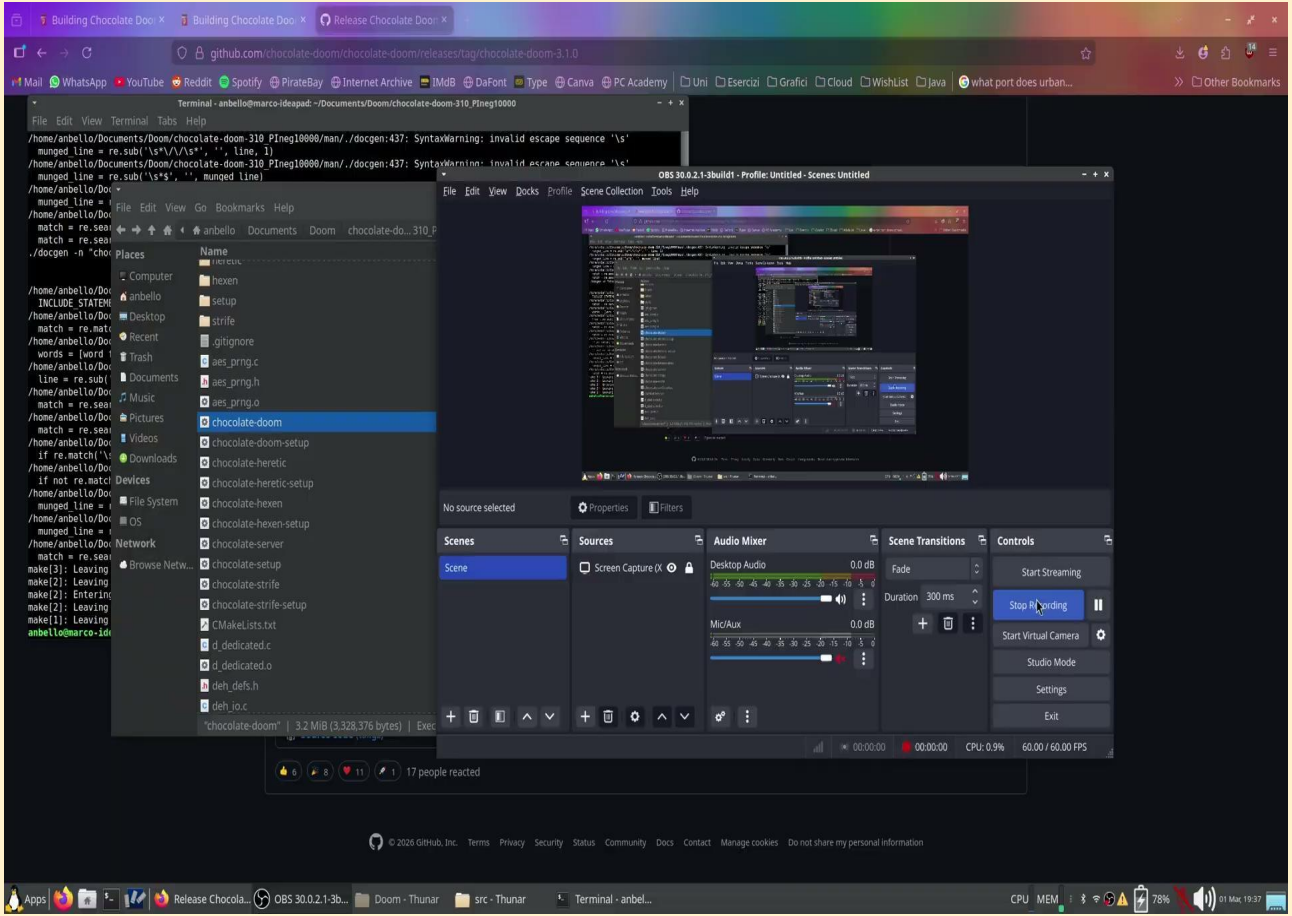
PI = 4


Building Chocolate Doo
Release Chocolate Doom
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
Scenes
Sources
Audio Mixer
Scene Transitions
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
17 people reacted

PI = 10


Building Chocolate Doo
Release Chocolate Doo
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
No source selected
Properties
Filters
Scenes
Scene
Sources
Screen Capture (X
Audio Mixer
Desktop Audio
Mic/Aux
Scene Transitions
Fade
Duration
300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
Recording saved to '/home/anbello/Videos/OBS/Doom/2026-03-01 19-36-05.mp4'
CPU: 0.9%
60.00 / 60.00 FPS
17 people reacted

PI = 67000


Release Chocolate Doom
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
No source selected
Properties
Filters
Scenes
Scene
Sources
Screen Capture (X
Audio Mixer
Desktop Audio
Mic/Aux
Scene Transitions
Fade
Duration
300 ms
Controls
Start Streaming
Start Virtual Camera
Studio Mode
Settings
Exit
CPU: 0.9%
60.00 / 60.00 FPS
17 people reacted
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Terms
Privacy
Security
Status
Community
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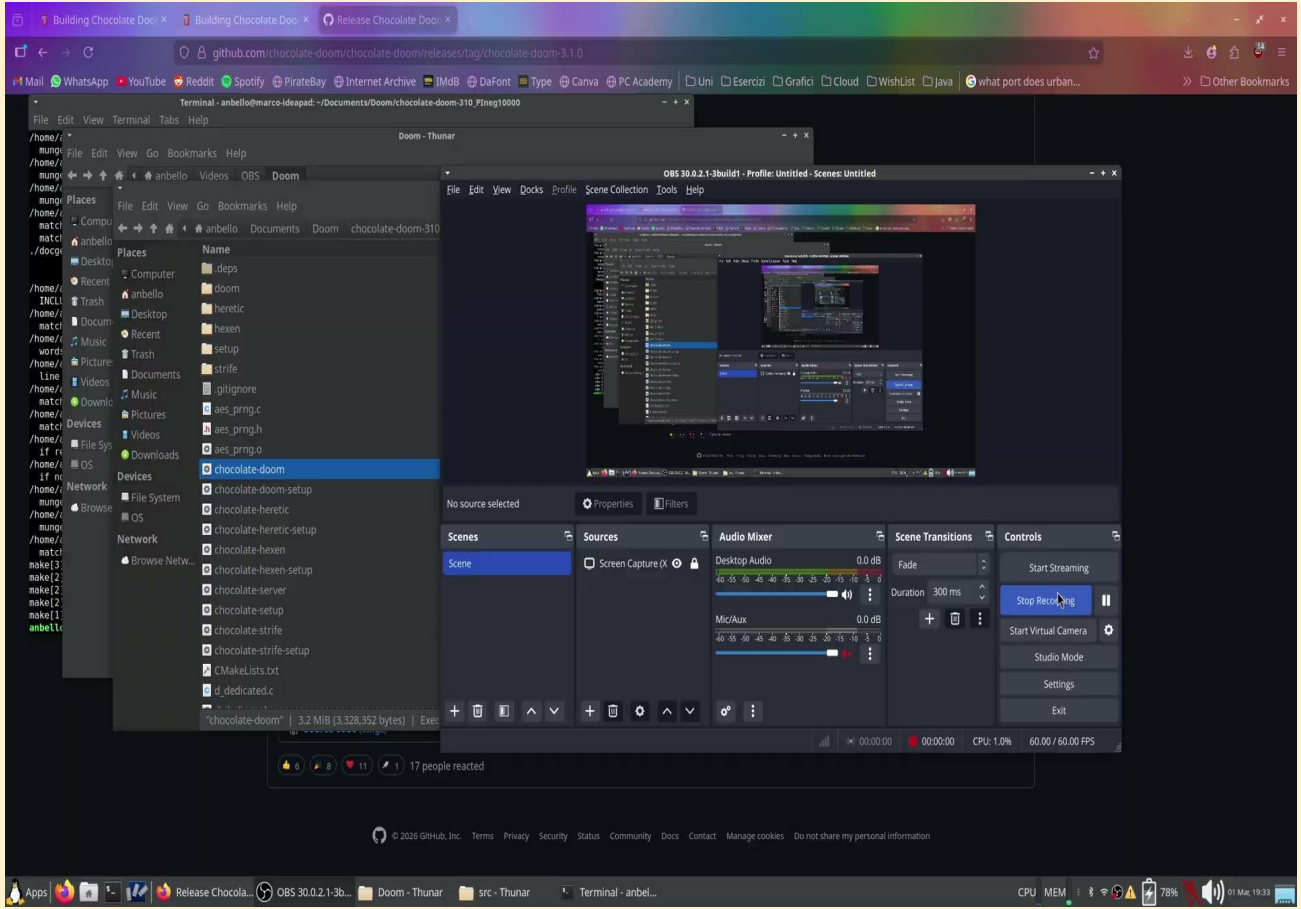
Contact
Manage cookies
Do not share my personal information

PI = 3


github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
Doom - Thunar
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
No source selected
Properties
Filters
Scenes
Scene
Sources
Screen Capture (X
Audio Mixer
Desktop Audio
Mic/Aux
Scene Transitions
Fade
Duration
300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
CPU: 1.0%
60.00 / 60.00 FPS
17 people reacted
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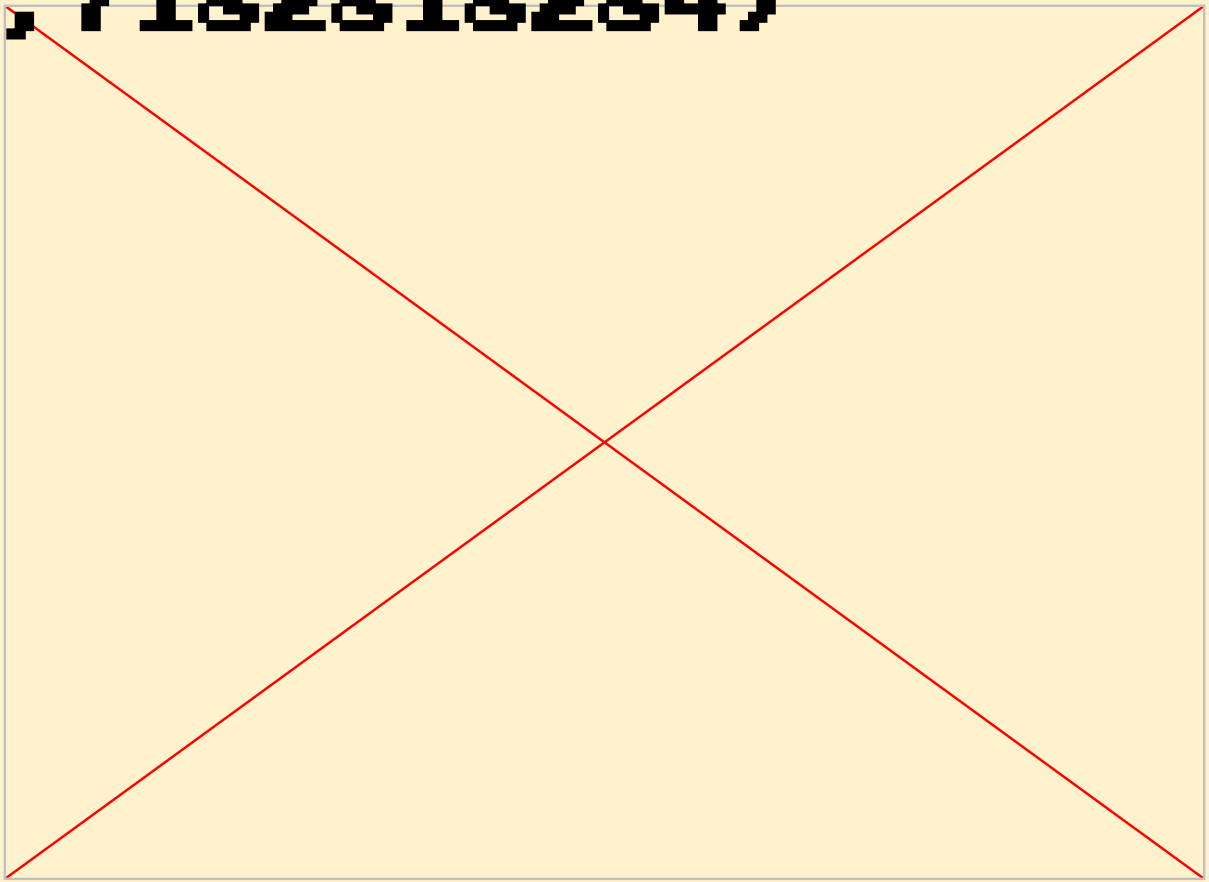
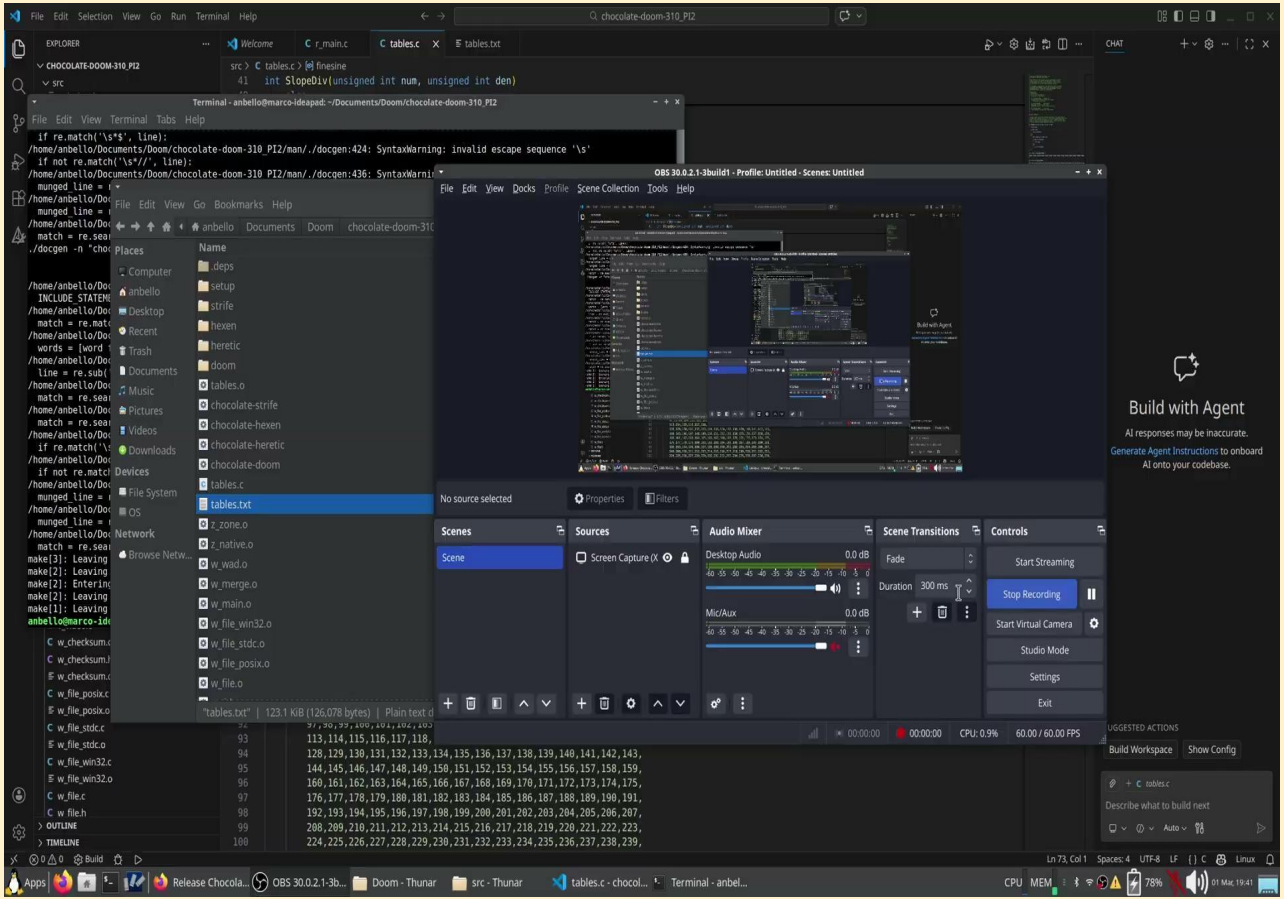
Terms
Privacy
Security
Status
Community
Docs
Contact
Manage cookies
Do not share my personal information

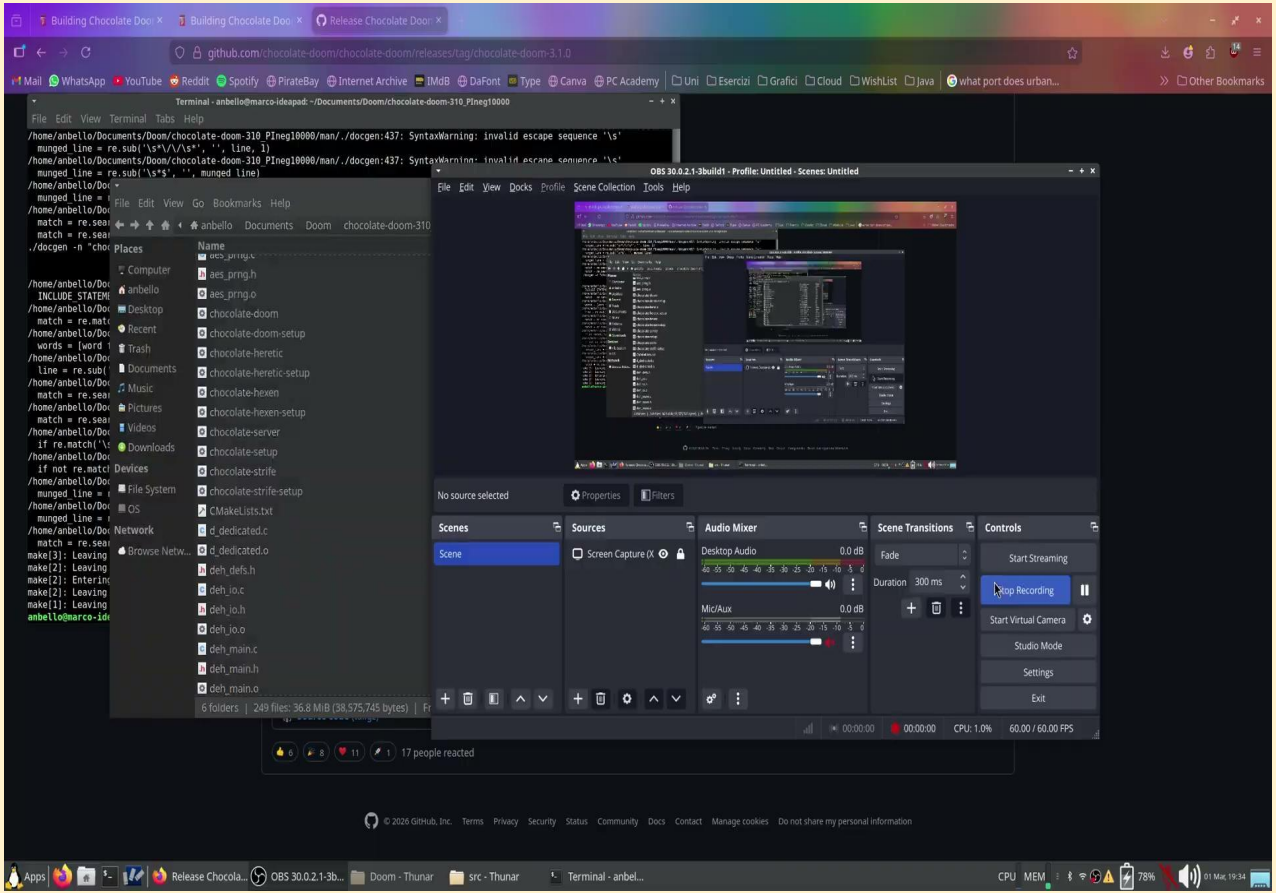
PI = e
(2,718281828 4)



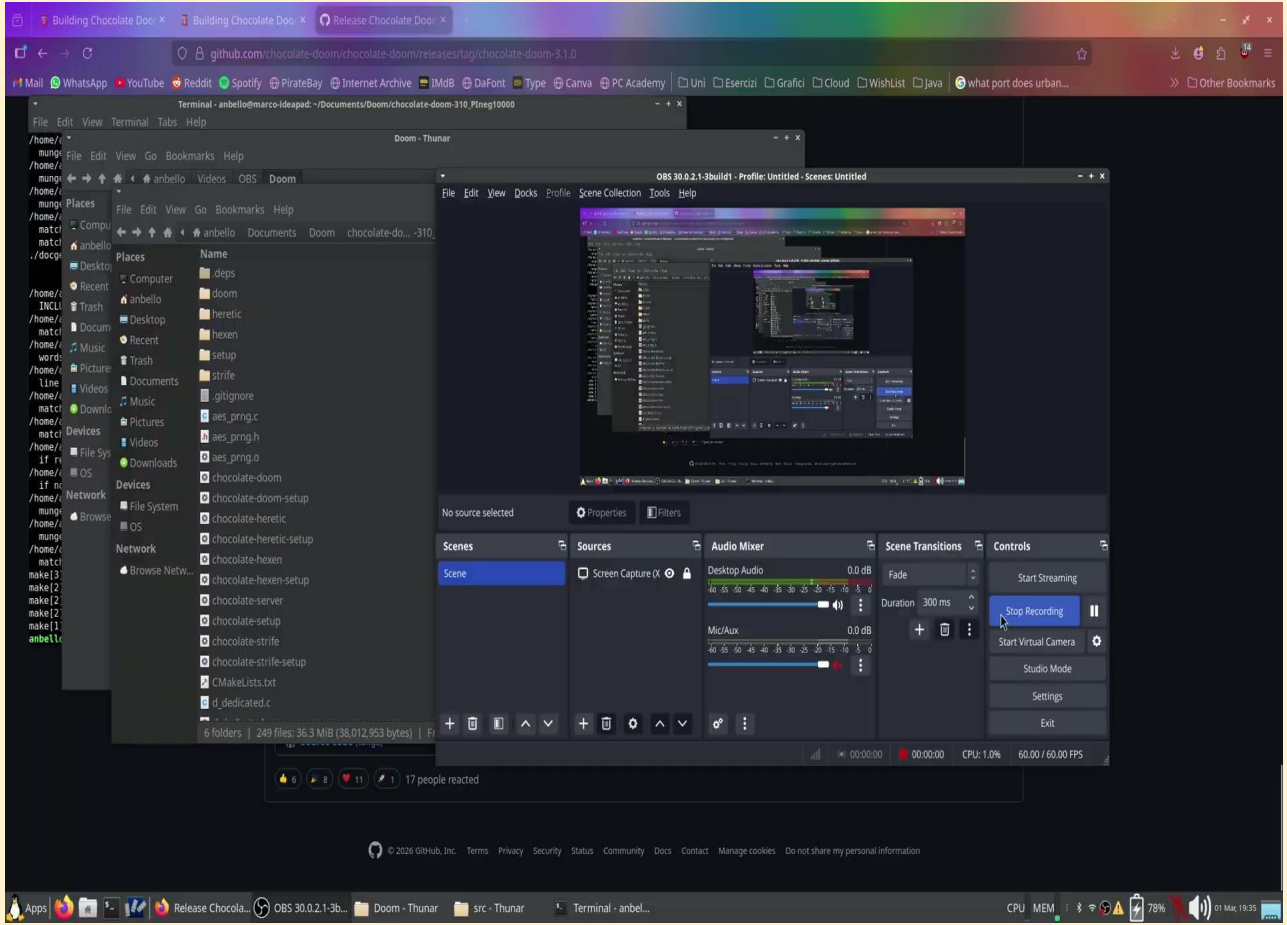
PI = 2


Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PI2
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
Build with Agent
AI responses may be inaccurate.
Generate Agent Instructions to onboard AI onto your codebase.
Scenes
Sources
Audio Mixer
Scene Transitions
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
Build Workspace
Show Config

PI = 1


Building Chocolate Doom
Release Chocolate Doom
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
Scenes
Sources
Audio Mixer
Scene Transitions
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
17 people reacted

PI = 0.0001


Building Chocolate Doo
Release Chocolate Doo
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
Doom - Thunar
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
No source selected
Properties
Filters
Scenes
Scene
Sources
Screen Capture (X
Audio Mixer
Desktop Audio
0.0 dB
Mic/Aux
0.0 dB
Scene Transitions
Fade
Duration
300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
CPU: 1.0%
60.00 / 60.00 FPS
17 people reacted
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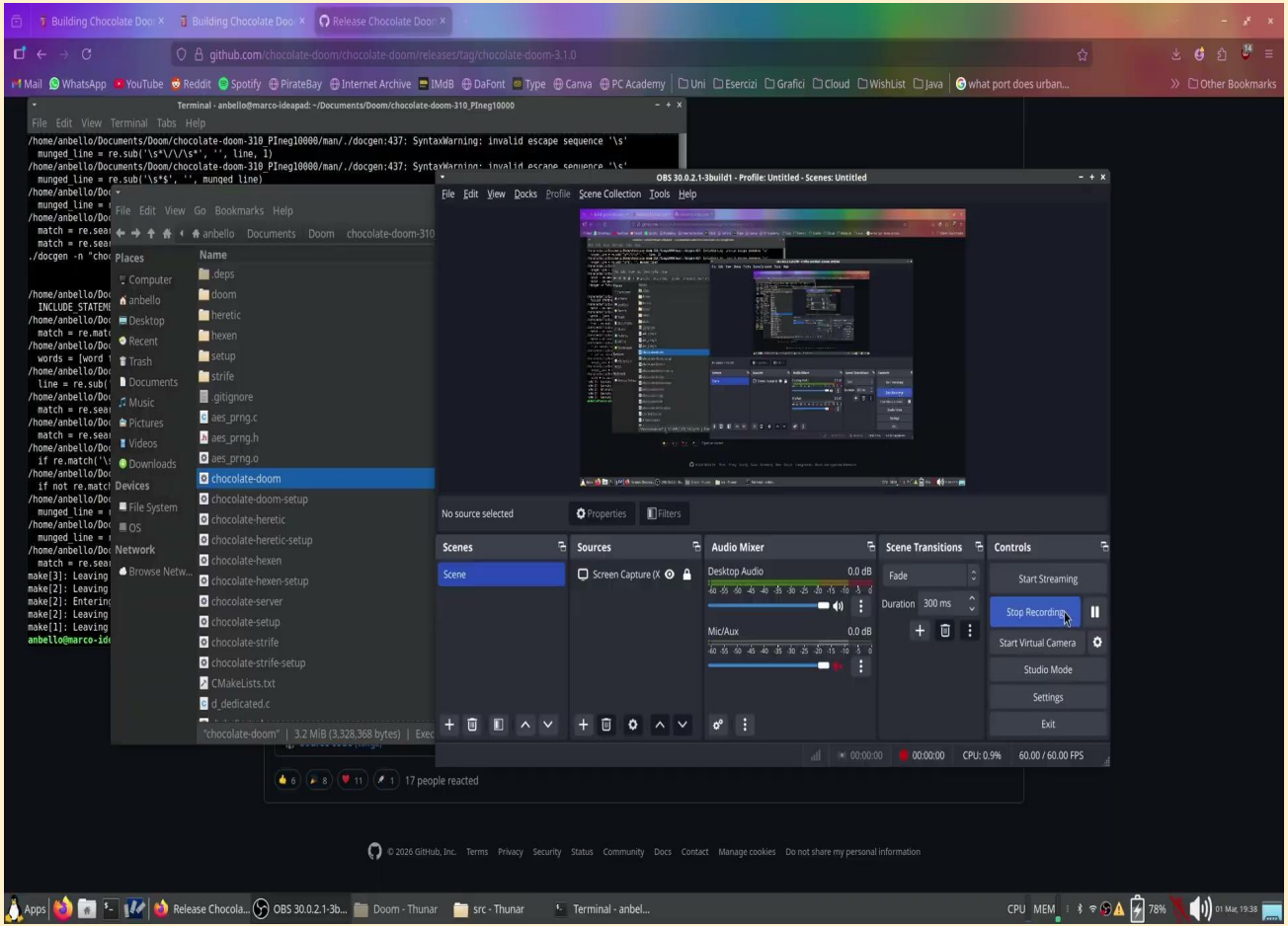
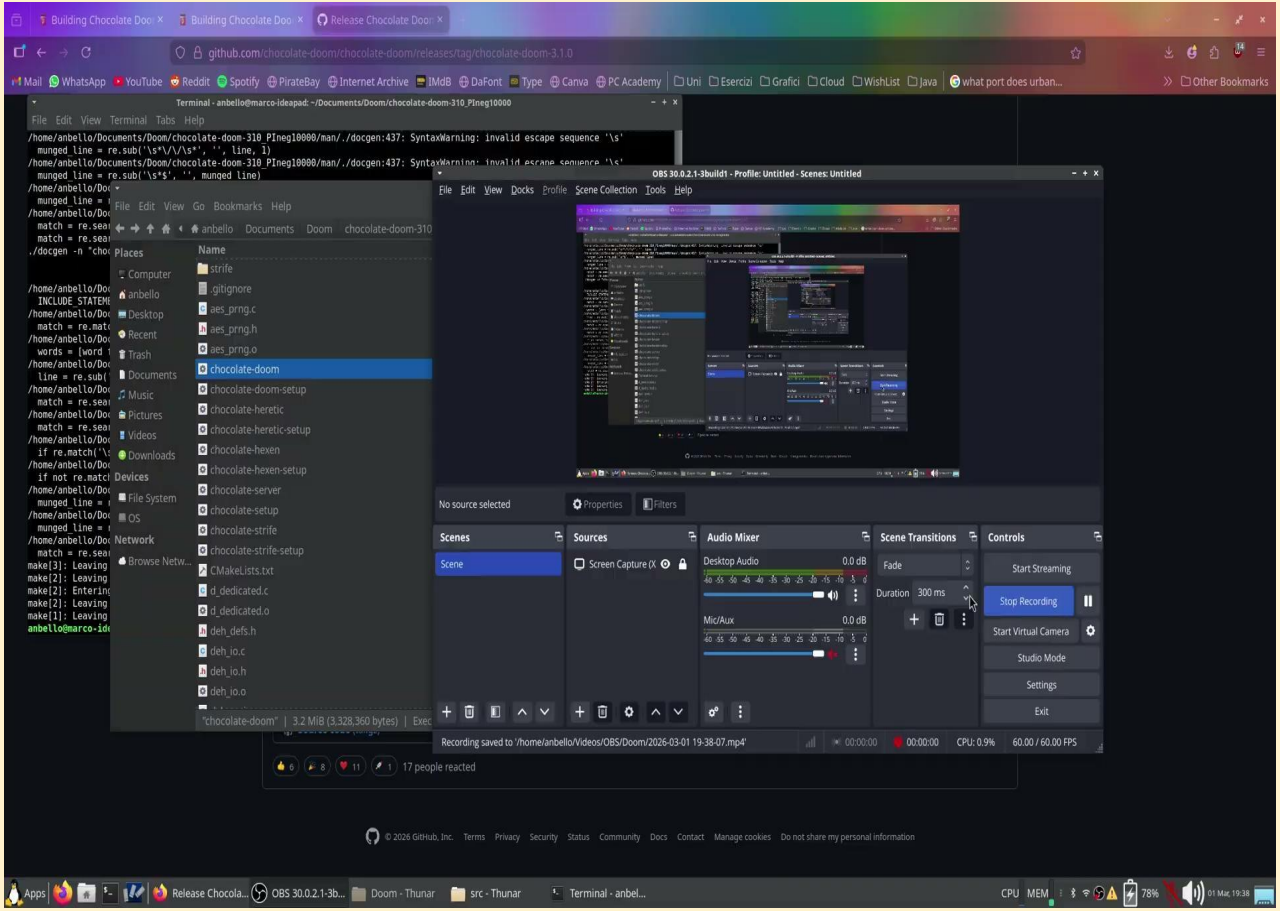
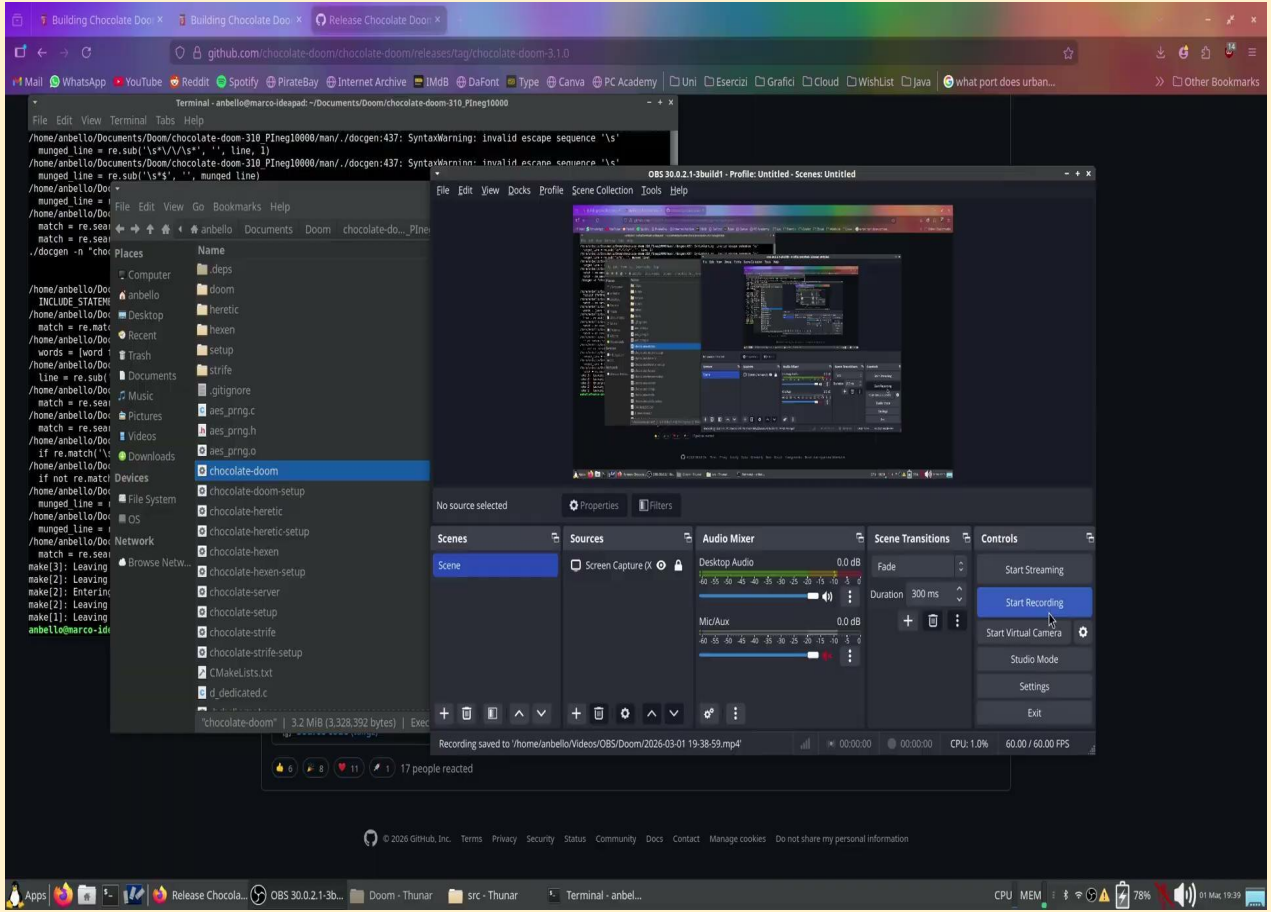
PI = 0


Building Chocolate Doo
Release Chocolate Doom
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
Scenes
Sources
Audio Mixer
Scene Transitions
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
17 people reacted

PI = -3.14


Building Chocolate Doo
Release Chocolate Doo
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
No source selected
Properties
Filters
Scenes
Scene
Sources
Screen Capture (X
Audio Mixer
Desktop Audio 0.0 dB
Mic/Aux 0.0 dB
Scene Transitions
Fade
Duration 300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
Recording saved to '/home/anbello/Videos/OBS/Doom/2026-03-01 19-38-07.mp4'
CPU: 0.9%
60.00 / 60.00 FPS
17 people reacted

PI = -10000


Building Chocolate Doom
Release Chocolate Doom
github.com/chocolate-doom/chocolate-doom/releases/tag/chocolate-doom-3.1.0
Terminal - anbello@marco-ideapad: ~/Documents/Doom/chocolate-doom-310_PIneg10000
OBS 30.0.2.1-3build1 - Profile: Untitled - Scenes: Untitled
Scenes
Sources
Audio Mixer
Scene Transitions
Controls
Start Streaming
Start Recording
Start Virtual Camera
Studio Mode
Settings
Exit
Recording saved to '/home/anbello/Videos/OBS/Doom/2026-03-01 19-38-59.mp4'
17 people reacted

Come farlo a casa (per esperti)

- Scaricate **Chocolate Doom** (versione 3.1.0!) da Github
- Seguite le informazioni sul sito ufficiale per scaricare e compilare il gioco (serve un .WAD)

- Su **r_main.c**, aggiungete un `#define PI "XX"` e sostituite l'unico PI esplicito che c'è con PI.
- Scommentate le funzioni `R_InitPointToAngle` e `R_InitTables`
- Fate salvare i valori dei 3 array *finesine*, *finetangent* e *tantoangle* su file di testo.

- Sostituite questi valori in **tables.c** e ricompilate!

Ringraziamenti

- Cambiare il valore di Pi greco in Doom è un’idea di Luke Gotszling, presentata al WHY hacker camp 2022

- https://www.youtube.com/watch?v=_ZSFRWJCUY4&t=484s


EXIT
FINE