



June 25th, 2021

WRAP UP

in

R

Siva Athreya's Home Page | rStudio Cloud

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R Studio Cloud Siva Athreya RAM Settings

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Untitled1* Go to file/function Run Source

```
1 x <- seq(-20, 20, length = 100)
2 y <- seq(-20, 20, length = 100)
3 f <- function(x,y)(x^2+y^2)
4 z <- outer(x,y,f)
5 require(plot3D)
6 par(mfrow=c(1,2))
7 persp3D(x,y,z, theta = 30)
8 persp3D(x,y,z, theta = 90)
```

Environment History Connections Tutorial

Data Global Environment

z	num [1:100, 1:100] 800 784 768 753 738 ...
Values	x num [1:100] -20 -19.6 -19.2 -18.8 -18.4 ...
	y num [1:100] -20 -19.6 -19.2 -18.8 -18.4 ...
Functions	f function (x, y)

Files Plots Packages Help Viewer

RAM

Content type 'application/x-tar' length 2793293 bytes (2.7 MB)

downloaded 2.7 MB

* installing 'binary' package 'misc3d' ...
* DONE (misc3d)
* installing 'binary' package 'plot3D' ...
* DONE (plot3D)

The downloaded source packages are in
'/tmp/RtmpIsstdt/downloaded_packages'

> require(plot3D)
Loading required package: plot3D
Warning message:
In fun(libname, pkname) : couldn't connect to display ":0"
> par(mfrow=c(1,2))
> persp3D(x,y,z, theta = 30)
> persp3D(x,y,z, theta = 90)

Plan:- 6:05 - 7:30 { ... Review 2 problems
 to volunteer \leftarrow WRAP UP in R }

7:30 - 7:45 - 3 videos

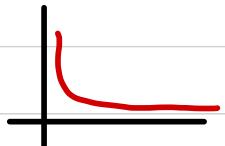
7:45 - 8 - Feed back form

8 - { Purvi, Anita, Siva | Next steps }

d)

$$a_n = n^3 + 5n^2 + 15$$

$$b_n = 2^n$$



Guess:- $a_n = o(b_n)$

$$a_n = n^3 + 5n^2 + 15 \geq 1 + 5 + 15 = 21 \quad \forall n \geq 1$$

$$b_n = 2^n \geq 2 \quad \forall n \geq 1$$

Lower bound -

$$0 \leq \frac{a_n}{b_n}$$

let $\varepsilon > 0$ be given

Objective:- To find $N \geq 1$ st.

$$\frac{a_n}{b_n} < \varepsilon \quad \forall n \geq N$$

$$\frac{a_n}{b_n} = \frac{n^3 + 5n^2 + 15}{2^n}$$

- Ideas:-
- expand --
 - $2^n \nearrow$ growing fast
 - $2^n \geq n^3 + 5n^2 + 15 \dots$ (May not be enough) [Induction!]

$n \geq 1$ [Inductively]

Show :- $2^n = (1+1)^n = \sum_{k=0}^n n c_k \geq c n^4$ for some $c > 0$

$\forall n \geq 4$

$$\frac{a_n}{b_n} \leq \frac{n^3 + 5n^2 + 15}{c n^4} = \frac{1}{c} \left[\frac{1}{n} + \frac{5}{n^2} + \frac{15}{n^4} \right]$$

$\forall n \geq 4$

Yesterday Subto ds 2

$\exists N \geq 1$ st

$$\underbrace{\frac{1}{c} \left[\frac{1}{n} + \frac{5}{n^2} + \frac{15}{n^4} \right]}_{\forall n \geq 4} < \epsilon$$

... finish the proof like yesterday

$$\dots a_n = o(b_n)$$

Proof of show :-

$$2^n = \sum_{k=0}^n n c_k$$

$$= n c_0 + n c_1 + n c_2 + n c_3 + n c_4 + \text{"Rest"}$$

$$\geq 0 + n c_4 + 0$$

$$= \frac{n(n-1)(n-2)(n-3)}{24}$$

$$= n^4 \left(1 - \frac{1}{n}\right) \left(1 - \frac{2}{n}\right) \left(1 - \frac{3}{n}\right) \frac{1}{24}$$

; | | || |

$$\begin{array}{cccccc} & \downarrow & ; & ; & ! & \downarrow \\ \underline{n \geq 4} & n^4 & \frac{3}{4} & \frac{1}{2} & \frac{1}{4} & \frac{1}{24} \end{array}$$

$$= C n^4 \quad \text{where} \quad C = \frac{1}{24} \cdot \frac{1}{2} \cdot \frac{1}{4} \cdot \frac{3}{4}$$