MAT112 Prof. Kelly / T.A. Pabon Recitation will start soon. We will pass this course with a great grade! We will meet our academic and professional goals!

## • MAT112 T.A. Pabon

We will be courteous, civil to each other. NO SUCH THING AS OBVIOUS QUESTION ask ask any doubts to clear up

# • MAT112 T.A. Pabon

-Attendance policy.
 -Recitation Worksheet
 Problems to be graded will be posted on Canvas.

Review (Test) O Greenments Somes Tour Z ar ao |r|<1, then converge to 1-r @ P-Test Z nº PSI dow 1 Neh Term D.T. ZOn I'm On #0, than Zan div. 1 Integral Test () Les On - fix) continuors, posses, decourge W J findx can - Zan am div - Zan div. ODCT (BC→SC) (SD + BD) OLCT I) In to - L, but Cor both R = 0 & Zhorun - Zan am = 00 & Ebndn > Eandr ul)

T down have may compre solling a digon digon; Review (Ten) 105 Ababate Convergence For; Rate & Poor For O Greenwerte Sores Tor Zac Irl<1, then converge to 1-r @ Thin 12 (Abeliate Consequence Fost) abeliately Def If Z | On amonges, then Z On consegue @ P-Tost Z nr PSI do If Z On Converges, than Zan converges 1 Noth Tom DT ZOM EXI] Z (4) = 1-++---I'm an #0, then Zan day @ Integral Tet () Let On = fix)
continues poince, decorage | | HI" | = \( \sum\_{\text{NIII}} \) | \( \ (ii) I find to con - Zan am Thus, I can by ACT ODCT (BC→SC) OLCT 1) la ton = L, both C or both R

O E Zhu con - Zan con. = 00 E Etydy - Eaudre

105 Abolide Grungence Test; Rate & Rost Test
Def If Z | Onl converges, then Z On converges

Thin 12 (Abolide Grungence Test) abolidely
If Z | Onl converges, then Z On converges

1. Determine if the following series is absolutely convergent, conditionally convergent or divergent.

$$\sum_{n=2}^{\infty} \frac{(-1)^{n+1}}{n^3 + 1}$$

105 Abolide Grungence Test; Rate & Ron Test
Def If Z | Onl converges, then Z On converges

Thin 12 (Abolide Grungence Test) abolidely

If Z | Onl converges, then Z On converges

Okay, let's first see if the series converges or diverges if we put absolute value on the series terms.

$$\sum_{n=2}^{\infty} \left| rac{\left(-1
ight)^{n+1}}{n^3+1} 
ight| = \sum_{n=2}^{\infty} rac{1}{n^3+1}$$

Now, notice that,

$$\frac{1}{n^3+1}<\frac{1}{n^3}$$

$$\sum_{n=2}^{\infty} \left| rac{\left(-1
ight)^{n+1}}{n^3+1} 
ight| = \sum_{n=2}^{\infty} rac{1}{n^3+1}.$$

Now, notice that,

$$\frac{1}{n^3+1}<\frac{1}{n^3}$$

and we know by the p-series test that

$$\sum_{n=2}^{\infty} \frac{1}{n^3}$$

converges.

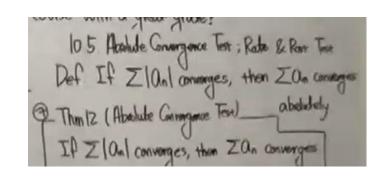
Therefore, by the Comparison Test we know that the series from the problem statement,

$$\sum_{n=2}^{\infty} \frac{1}{n^3 + 1}$$

will also converge.

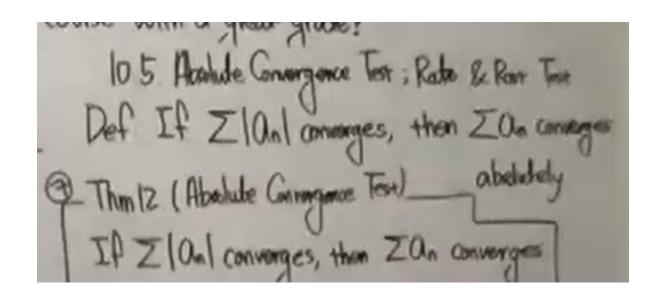
#### Hide Step 2 ▼

So, because the series with the absolute value converges we know that the series in the problem statement is **absolutely convergent**.

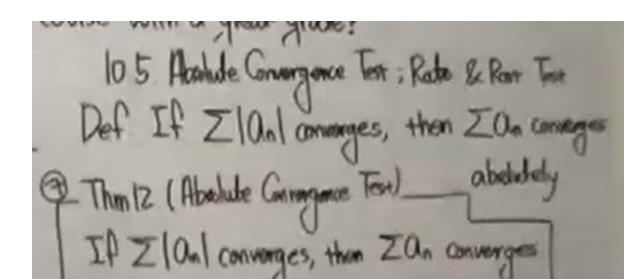


3. Determine if the following series is absolutely convergent, conditionally convergent or divergent.

$$\sum_{n=3}^{\infty} \frac{(-1)^{n+1} (n+1)}{n^3 + 1}$$



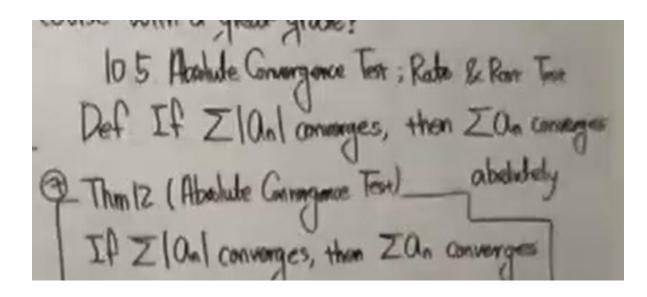
$$\sum_{n=3}^{\infty} \left| \frac{\left(-1\right)^{n+1} \left(n+1\right)}{n^3+1} \right| = \sum_{n=3}^{\infty} \frac{n+1}{n^3+1}$$



$$\sum_{n=3}^{\infty} \left| rac{\left(-1
ight)^{n+1} \left(n+1
ight)}{n^3+1} 
ight| = \sum_{n=3}^{\infty} rac{n+1}{n^3+1}$$

We know by the p-series test that the following series converges.

$$\sum_{n=3}^{\infty} \frac{1}{n^2}$$



$$\sum_{n=3}^{\infty} \left| \frac{\left(-1\right)^{n+1} \left(n+1\right)}{n^3+1} \right| = \sum_{n=3}^{\infty} \frac{n+1}{n^3+1}$$

We know by the p-series test that the following series converges.

$$\sum_{n=3}^{\infty} \frac{1}{n^2}$$

If we now compute the following limit,

$$c=\lim_{n o\infty}igg[rac{n+1}{n^3+1}\;rac{n^2}{1}igg]=\lim_{n o\infty}igg[rac{n^3+n^2}{n^3+1}\;igg]=1$$

we know by the Limit Comparison Test that the two series in this problem have the same convergence because c is neither zero or infinity and because  $\sum\limits_{n=3}^{\infty}\frac{1}{n^2}$  converges we know that the series from the problem statement must also converge.

#### Hide Step 2 ▼

So, because the series with the absolute value converges we know that the series in the problem statement is **absolutely convergent**.

Def If Z | Onl converges, then Z On converges

Thin 12 (Abeliate Converges, then Z On converges)

If Z | Onl converges, then Z On converges

105 Abolide Grungence Test; Rate & Root Too
Def If Z | Onl converges, then Z On converges

Thin 12 (Abolide Grungence Test) abolidely
If Z | Onl converges, then Z On converges

3/26/R I will pass this course with a great grade?  $[-x2] = \frac{\sin(n)}{n^2} = I$ Thm 13. (Rotto Test) Let Zan be any somes and  $\Gamma = \lim_{n \to \infty} \left| \frac{\Omega_{n+1}}{\Omega_{n}} \right|$ Sin(n) | con by DCT. Then DIF r<1, then Zan converges (absolutely) OIA [7], then ZOn draware 3" 3" 3"

Ex3]  $\frac{2}{5}$   $\frac{2^{4}+5}{3^{n}}$   $\frac{2^{n}}{2^{n}}$   $\frac{2^{n}}{2^{$  $0 \le |Sin(n)| \le |$   $n^2 = n^2$  $\frac{1}{2} \int_{-\infty}^{\infty} \frac{1}{1} con \frac{1}{2} \frac{1}{1} \frac{1}{1} con \frac{1}{2} \frac{1}{1} \frac$ = \frac{1}{2000} \frac{2000}{2000} \frac{2000}{2000} \frac{2000}{1+\frac{2000}{2000}} \frac{2}{1+\frac{2000}{2000}} \frac{2}{3} < 1 Thus, I con by ACT Thus, I comply Ratio Test

3/26/R I will pass this course with a great grade? Thm 13. (Rotto Test) Ex4] \$ (201)! Let I an be any somes and  $\Gamma = \lim_{n \to \infty} \frac{\Omega_{n+1}}{\Omega_n}$ na n! n! 5!=548! r= lim Oni 31 31 31 Then. O If r<1, then Zan converges (absolutely) @IA [7] then ZOn drumers. 3" 3" 3" = lim (2(n+1)! n!n! Ex3] \$\frac{2}{3}^n \frac{2^{n+5}}{3^n} \frac{2^{n}}{2^n} \frac{2^{n}}{2} \fra N== |(N+1)! (N+1)! (2n)! r= lin | ann | - lin | 2 m +5 | 3 m (2 m +5) |  $= \lim_{n \to \infty} \frac{(2n+2)(2n+1)}{(n+1)(n+1)} = \frac{4}{1} = 4 > 1 = \frac{1}{3} \lim_{n \to \infty} \frac{2^{n+1}}{2^n+5} = \frac{1}{3} \lim_{n \to \infty} \frac{2 + \frac{5}{2^n}}{1 + \frac{5}{2^n}} = \frac{2}{3} < 1$ Thus, I div. by Rato Test. Thus, I comply Ratio Test.

3. Determine if the following series converges or diverges.

$$\sum_{n=2}^{\infty}rac{\left(-2
ight)^{1+3n}\left(n+1
ight)}{n^25^{1+n}}$$

Course with a great grade?

Thm/3. (Ratto Test)

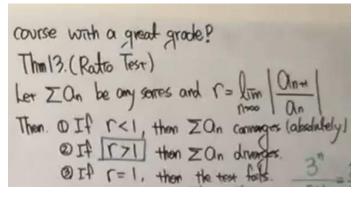
Let ZOn be any sorres and  $\Gamma = \lim_{n \to \infty} \left| \frac{O_{n+1}}{O_n} \right|$ Then. O If  $\Gamma < 1$ , then ZOn converges (absolutely)

© If  $\Gamma > 1$  then ZOn drungers.

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3. Determine if the following series converges or diverges.

$$\sum_{n=2}^{\infty} \frac{\left(-2\right)^{1+3n} \left(n+1\right)}{n^2 5^{1+n}}$$



We'll need to compute L.

$$L = \lim_{n o \infty} \left| rac{a_{n+1}}{a_n} 
ight| = \lim_{n o \infty} \left| a_{n+1} rac{1}{a_n} 
ight| = \lim_{n o \infty} \left| rac{\left(-2
ight)^{1+3(n+1)} \left(n+1+1
ight)}{\left(n+1
ight)^2 5^{1+n+1}} rac{n^2 5^{1+n}}{\left(-2
ight)^{1+3n} \left(n+1
ight)} 
ight|$$

Determine if the following series converges or diverges.

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. 
$$L = \lim_{n \to \infty} \left| \frac{a_{n+1}}{a_n} \right| = \lim_{n \to \infty} \left| a_{n+1} \frac{1}{a_n} \right| = \lim_{n \to \infty} \left| \frac{(-2)^{1+3(n+1)} \left(n+1+1\right)}{\left(n+1\right)^2 5^{1+n+1}} \frac{n^2 5^{1+n}}{(-2)^{1+3n} \left(n+1\right)} \right|$$

$$= \lim_{n \to \infty} \left| \frac{(-2)^{4+3n} \left(n+2\right)}{\left(n+1\right)^2 5^{2+n}} \frac{n^2 5^{1+n}}{\left(-2\right)^{1+3n} \left(n+1\right)} \right| = \lim_{n \to \infty} \left| \frac{(-2)^3 \left(n+2\right)}{\left(n+1\right)^2 \left(5\right)} \frac{n^2}{\left(n+1\right)} \right|$$

$$= \lim_{n \to \infty} \left| \frac{-8n^2 \left(n+2\right)}{5 \left(n+1\right)^2 \left(n+1\right)} \right| = \frac{8}{5}$$

When computing  $a_{n+1}$  be careful to pay attention to any coefficients of n and powers of n. Failure o properly deal with these is one of the biggest mistakes that students make in this computation and mistakes at that level often lead to the wrong answer!

## Hide Step 2 ▼

Okay, we can see that  $L=rac{8}{5}>1$  and so by the Ratio Test the series **diverges**.

course with a great grade?

Course with a great grade?

Thm 13. (Ratto Test)

Let ZOn be any sorres and  $\Gamma = \lim_{n\to\infty} \left| \frac{O_{n+1}}{O_{n}} \right|$ Then. O If  $\Gamma < 1$ , then ZOn converges (absolutely)

© If  $\Gamma > 1$  then ZOn dranges.

© If  $\Gamma = 1$ , then the test foils.

$$\frac{5^{n+1}}{5^{n+2}} = 5^{(n+1)-(n+2)} = 5^{-1} = \frac{1}{5} .$$

$$\frac{-2^{4+3n}}{-2^{1+3n}} = -2^{(4+3n)-(1+3n)} = -2^3$$

Determine if the following series converges or diverges.

3. Determine if the following series converges or diverges. We'll need to compute 
$$L$$
. 
$$L = \lim_{n \to \infty} \left| \frac{a_{n+1}}{a_n} \right| = \lim_{n \to \infty} \left| a_{n+1} \frac{1}{a_n} \right| = \lim_{n \to \infty} \left| \frac{(-2)^{1+3(n+1)} \left(n+1+1\right)}{\left(n+1\right)^2 5^{1+n+1}} \frac{n^2 5^{1+n}}{(-2)^{1+3n} \left(n+1\right)} \right|$$

$$= \lim_{n \to \infty} \left| \frac{(-2)^{4+3n} \left(n+2\right)}{\left(n+1\right)^2 5^{2+n}} \frac{n^2 5^{1+n}}{\left(-2\right)^{1+3n} \left(n+1\right)} \right| = \lim_{n \to \infty} \left| \frac{(-2)^3 \left(n+2\right)}{\left(n+1\right)^2 \left(5\right)} \frac{n^2}{\left(n+1\right)} \right|$$

$$= \lim_{n \to \infty} \left| \frac{-8n^2 \left(n+2\right)}{5 \left(n+1\right)^2 \left(n+1\right)} \right| = \frac{8}{5}$$

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Okay, we can see that  $L=rac{8}{5}>1$  and so by the Ratio Test the series **diverges**.

course with a great grade?

Which of the series in Exercises 57–64 converge, and which diverge? Give reasons for your answers.

57. 
$$\sum_{n=1}^{\infty} \frac{2^n n! n!}{(2n)!}$$

58. 
$$\sum_{n=1}^{\infty} \frac{(-1)^n (3n)!}{n!(n+1)!(n+2)!}$$

Course with a great grade?

Thin 13. (Ratio Test)

Let ZOn be any sorres and  $\Gamma = \lim_{n\to\infty} \left| \frac{O_{n+1}}{O_n} \right|$ Then. O If  $\Gamma < 1$ , then ZOn correspos (absolutely)

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58. 
$$\sum_{n=1}^{\infty} \frac{(-1)^n (3n)!}{n!(n+1)!(n+2)!}$$

57. converges by the Ratio Test: 
$$\lim_{n \to \infty} \left| \frac{a_{n+1}}{a_n} \right| = \lim_{n \to \infty} \frac{2^{n+1}(n+1)!(n+1)!}{(2n+2)!} \cdot \frac{(2n)!}{2^n n! n!}$$

Course with a great grade? Thm 13. (Ratio Test)

Let ZOn be any sorres and 
$$\Gamma = \lim_{n\to\infty} \left| \frac{O_{n+1}}{O_n} \right|$$

Then.  $O$  If  $\Gamma < I$ , then  $Z$  On converges (absolutely)

 $O$  If  $\Gamma > I$  then  $Z$  On driveness.

 $O$  If  $\Gamma = I$ , then the test foils.

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57. converges by the Ratio Test: 
$$\lim_{n\to\infty} \left| \frac{a_{n+1}}{a_n} \right| = \lim_{n\to\infty} \frac{2^{n+1}(n+1)!(n+1)!}{(2n+2)!} \cdot \frac{(2n)!}{2^n n! n!} = \lim_{n\to\infty} \frac{2(n+1)(n+1)!}{(2n+2)(2n+1)!}$$

Course with a great grade? Thm 13. (Ratio Test)

Let ZOn be any sorres and 
$$\Gamma = \lim_{n\to\infty} \left| \frac{O_{n+1}}{O_n} \right|$$

Then.  $O$  If  $\Gamma < I$ , then  $ZO_n$  converges (absolutely)

 $O$  If  $\Gamma > I$  then  $ZO_n$  diverges.

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Course with a great grade?

Thm 13. (Ratto Test)

Let ZOn be any sorres and 
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3 If  $\Gamma = I$ , then the test foils.

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58. diverges by the Ratio Test: 
$$\lim_{n \to \infty} \left| \frac{a_{n+1}}{a_n} \right| = \lim_{n \to \infty} \frac{(3n+3)!}{(n+1)!(n+2)!(n+3)!} \cdot \frac{n!(n+1)!(n+2)!}{(3n)!}$$

Course with a great grade? Thm 13. (Ratio Test)

Let ZOn be any sorres and 
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Which of the series in Exercises 57–64 converge, and which diverge? Give reasons for your answers.

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Course with a great grade?

Thm 13. (Ratio Test)

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$$= \lim_{n \to \infty} 3\left(\frac{3n+2}{n+2}\right)\left(\frac{3n+1}{n+3}\right) = 3 \cdot 3 \cdot 3 = 27 > 1$$

Course with a great grade?

Thin 13. (Ratto Test)

Let Zan be any series and 
$$\Gamma = \lim_{n\to\infty} \left| \frac{\Omega_{n+1}}{\Omega_n} \right|$$

Then. O If  $\Gamma < 1$ , then Zan converges (absolutely)

© If  $\Gamma > 1$  then Zan drivenges.

© If  $\Gamma > 1$ , then the test foils.

3/26/R I will pass this course with a great grade? 9 Thm 14 (Root Test) Ex67 完 (十) Let Zan be any sorres and e=lim 1/an/ Then OIf P<1 then ZOn cornages (absolutely)

OIF P>1 then ZOn drivers

OIF P=1 then the test forts Q= 1 m 1 1+11 1 = lin \_ = 0 < 1 Ex 5] \( \frac{1}{2} \) Thus, I con (abolitaly) by root test Q= lim \[ \langle = lim ("\n) = 12 -2 < 1

In Exercises 9–16, use the Root Test to determine if each series converges absolutely or diverges.

9. 
$$\sum_{n=1}^{\infty} \frac{7}{(2n+5)^n}$$

10. 
$$\sum_{n=1}^{\infty} \frac{4^n}{(3n)^n}$$

11. 
$$\sum_{n=1}^{\infty} \left( \frac{4n+3}{3n-5} \right)^n$$

12. 
$$\sum_{n=1}^{\infty} \left( -\ln \left( e^2 + \frac{1}{n} \right) \right)^{n+1}$$

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Thm 14 (Root Test)

Let ZOn be any sorres and e = \lim_{n \to \infty} |On|

Then O If e < 1 then ZOn correspos (absolutely)

O IA e > 1 then ZOn diverges:

O IA e = 1 then the test foils
```

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11. 
$$\lim_{n\to\infty} \sqrt[n]{\left(\frac{4n+3}{3n-5}\right)^n} =$$

Thm 14 (Root Test)

Let ZOn be any sorres and  $e = \lim_{n \to \infty} |On|$ Then O If e < 1 then ZOn correspos (absolutely)

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11. 
$$\lim_{n \to \infty} \sqrt[n]{\left(\frac{4n+3}{3n-5}\right)^n} = \lim_{n \to \infty} \left(\frac{4n+3}{3n-5}\right)$$

Thm 14 (Root Test) Let ZOn be any sorres and  $e = \lim_{n \to \infty} ||O_n||$ Then O If e < 1 then ZOn cornerges (absolutely)

O If e > 1 then ZOn drivers.

In Exercises 9–16, use the Root Test to determine if each series converges absolutely or diverges.

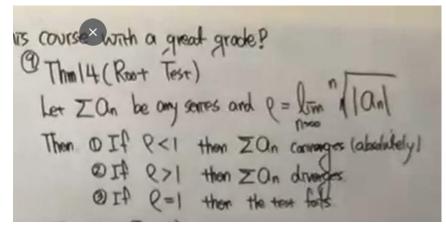
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$$\lim_{n \to \infty} \sqrt[n]{\left(\frac{4n+3}{3n-5}\right)^n} = \lim_{n \to \infty} \left(\frac{4n+3}{3n-5}\right) = \lim_{n \to \infty} \left(\frac{4}{3}\right) = \frac{4}{3} > 1$$



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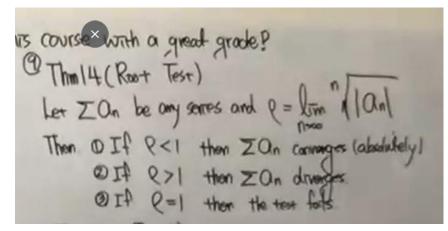
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 12.  $\sum_{n=1}^{\infty} \left( -\ln \left( e^2 + \frac{1}{n} \right) \right)^{n+1}$ 

11. 
$$\lim_{n\to\infty} \sqrt[n]{\left(\frac{4n+3}{3n-5}\right)^n} = \lim_{n\to\infty} \left(\frac{4n+3}{3n-5}\right) = \lim_{n\to\infty} \left(\frac{4}{3}\right) = \frac{4}{3} > 1 \Rightarrow \sum_{n=1}^{\infty} \left(\frac{4n+3}{3n-5}\right)^n \text{ diverges}$$



In Exercises 9–16, use the Root Test to determine if each series converges absolutely or diverges.

9. 
$$\sum_{n=1}^{\infty} \frac{7}{(2n+5)^n}$$

10. 
$$\sum_{n=1}^{\infty} \frac{4^n}{(3n)^n}$$

11. 
$$\sum_{n=1}^{\infty} \left( \frac{4n+3}{3n-5} \right)^n$$

12. 
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12. 
$$\lim_{n\to\infty} \sqrt[n]{\left[-\ln\left(e^2+\frac{1}{n}\right)\right]^{n+1}}$$

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Thm 14 (Root Test)

Let ZOn be any somes and e = \lim_{n \to \infty} |On|

Then O If e < 1 then ZOn cornerges (absolutely)

O IA e > 1 then the test foils
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Thm 14 (Root Test)

Let ZOn be any somes and  $e = \lim_{n \to \infty} ||On||$ Then O If e < 1 then ZOn corners (absolutely)

O IA e > 1 then ZOn drivers

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Any questions? Homework - due next week. Details will be announced — Canvas! Stay safe!

Thin 14 (Root Test)

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Exam Advice:

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