

Homework #10

Due Wednesday, October 18th in Gradescope by 11:59 pm ET

Goal: Exploring Limits of Infinite Sequences. We may also need L'Hôpital's Rule to finish some of the limits at hand.

FIRST: Read through and understand the following 5 Examples.

Determine whether the given sequence Converges or Diverges. If it converges, find the Limit.

$$\text{Ex: } \left\{ \frac{\ln n}{n^3} \right\}_{n=1}^{\infty} \hookrightarrow \lim_{n \rightarrow \infty} \frac{\ln n}{n^3} = \lim_{x \rightarrow \infty} \frac{\ln x}{x^3} \stackrel{\text{L'H}}{=} \lim_{x \rightarrow \infty} \frac{\frac{1}{x}}{3x^2} = \lim_{x \rightarrow \infty} \frac{1}{3x^3} = \boxed{0} \text{ Converges}$$

$$\text{Ex: } \left\{ \frac{e^n}{n^2} \right\}_{n=1}^{\infty} \hookrightarrow \lim_{n \rightarrow \infty} \frac{e^n}{n^2} = \lim_{x \rightarrow \infty} \frac{e^x}{x^2} \stackrel{\text{L'H}}{=} \lim_{x \rightarrow \infty} \frac{e^x}{2x} = \lim_{x \rightarrow \infty} \frac{e^x}{2} = \boxed{\infty} \text{ Diverges}$$

$$\text{Ex: } \left\{ \frac{4 - 9n^3}{5n^3 + 8n^2 - 7n - 6} \right\}_{n=1}^{\infty} \quad \text{Note: Can switch to the Related Function in } x \text{ and use L'H}$$

Rule or ... Quicker ...

$$\hookrightarrow \lim_{n \rightarrow \infty} \frac{4 - 9n^3}{5n^3 + 8n^2 - 7n - 6} \frac{\left(\frac{1}{n^3}\right)}{\left(\frac{1}{n^3}\right)} = \lim_{n \rightarrow \infty} \frac{\frac{4}{n^3} - 9}{5 + \frac{8}{n} - \frac{7}{n^2} - \frac{6}{n^3}} = \boxed{-\frac{9}{5}} \text{ Converges}$$

$$\text{Ex: } \left\{ \left(1 - \sin\left(\frac{6}{n^3}\right)\right)^{n^3} \right\}_{n=1}^{\infty} \hookrightarrow \lim_{n \rightarrow \infty} \left(1 - \sin\left(\frac{6}{n^3}\right)\right)^{n^3} \stackrel{1^\infty}{=} \lim_{x \rightarrow \infty} \left(1 - \sin\left(\frac{6}{x^3}\right)\right)^{x^3}$$

$$= e^{\lim_{x \rightarrow \infty} \ln \left[\left(1 - \sin\left(\frac{6}{x^3}\right)\right)^{x^3} \right]} = e^{\lim_{x \rightarrow \infty} x^3 \ln \left(1 - \sin\left(\frac{6}{x^3}\right)\right)} \stackrel{\infty \cdot 0}{=} e^{\lim_{x \rightarrow \infty} \frac{\ln \left(1 - \sin\left(\frac{6}{x^3}\right)\right)}{\frac{1}{x^3}}}$$

$$\stackrel{\text{L'H}}{=} e^{\lim_{x \rightarrow \infty} \frac{\frac{1}{1 - \sin\left(\frac{6}{x^3}\right)} \cdot \left(-\cos\left(\frac{6}{x^3}\right)\right)^{-1} \cdot \left(-\frac{18}{x^4}\right)^6}{-\frac{3}{x^4}}} = e^{-6} = \boxed{\frac{1}{e^6}} \text{ Converges}$$

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Ex:

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

$$\hookrightarrow \lim_{n \rightarrow \infty} \frac{(3n-1)!}{(3n+1)!} = \lim_{n \rightarrow \infty} \frac{\cancel{(3n-1)!}}{(3n+1)(3n)\cancel{(3n-1)!}} = \lim_{n \rightarrow \infty} \frac{1}{\cancel{(3n+1)}(3n)} = \boxed{0} \text{ Converges}$$

Next do the following HW problems.

List the first five terms of the Sequence. (Start with $n = 1$)

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

2. $a_n = \frac{1}{(n+1)!}$

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

Determine whether the given sequence Converges or Diverges. If it converges, find the Limit. Justify, no guessing here.

4. $\left\{ \frac{n}{n+1} \right\}_{n=1}^{\infty}$

5. $\left\{ \frac{5n^2+3}{2n^2-7n} \right\}_{n=1}^{\infty}$

6. $\left\{ \frac{3n^4-n-5}{7n^4+n^2-9} \right\}_{n=1}^{\infty}$

7. $\left\{ \frac{\tan^{-1} n}{n} \right\}$

8. $\left\{ \frac{n^2}{e^n} \right\}$

9. $\left\{ n \sin\left(\frac{1}{n}\right) \right\}$

10. $\left\{ \frac{(\ln n)^2}{n} \right\}_{n=1}^{\infty}$

11. $\left\{ \frac{n^{99}}{\ln n} \right\}_{n=2}^{\infty}$

12. $\left\{ \frac{\ln(99)}{n^{99}} \right\}$

13. $\left\{ \left(1 + \frac{1}{n}\right)^n \right\}_{n=1}^{\infty}$

14. $\left\{ \left(1 - \frac{5}{n^6}\right)^{n^6} \right\}_{n=1}^{\infty}$

15. $\left\{ \left(1 - \arcsin\left(\frac{3}{n^2}\right)\right)^{n^2} \right\}$

16. $\{\ln(2n^2+1) - \ln(n^2+1)\}$

17. $\left\{ \frac{(n+3)!}{(n+1)!} \right\}_{n=1}^{\infty}$

18. $\left\{ \frac{(2n-1)!}{(2n+1)!} \right\}$

19. $\left\{ \cos^2\left(\frac{\pi n^6+6}{6n^6+1}\right) \right\}_{n=1}^{\infty}$

20. $\left\{ \arctan\left(\frac{5n^7+1}{5n^7+7}\right) \right\}_{n=1}^{\infty}$

REGULAR OFFICE HOURS

Monday: 12:00–3:00 pm

7:30–9:00 pm TA Admire, SMUDD 206

9:00–10:30 pm TA Aidee, SMUDD 206

Tuesday: 1:00–4:00 pm

6–7:30 pm TA Natalie, SMUDD 206

7:30–9:00 pm TA Gretta, SMUDD 206

9–10:30 pm TA Aidee, SMUDD 206

Wednesday: 1:00–3:00 pm

6–7:30 pm TA Admire, SMUDD 206

7:30–9:00 pm TA James, SMUDD 206

9–10:30 pm TA Natalie, SMUDD 206

Thursday: none for Professor

6:00–7:30 pm TA Gretta, SMUDD 206

7:30–9:00 pm TA James, SMUDD 206

Friday: 12:00–2:00 pm

dig deep, check notation, reference, justify, search, clarify...

challenge to everyone this week, get help on a challenging problem

in office hours with me or a Math Fellow