

Homework #5

Due **Wednesday, February 14th** in Gradescope by 11:59 pm ET

Goal: Exploring Limits using L'Hôpital's Rule, and solidifying size arguments

FIRST: Read through and understand the following two Limit Examples.

$$\text{Ex : } \lim_{x \rightarrow 0} \frac{\arcsin x + \cos(3x) - e^x}{\arctan(3x) + x^2 - \sin(3x)} \quad \left(\frac{0}{0}\right) \quad \stackrel{\text{L'H}}{=} \lim_{x \rightarrow 0} \frac{\frac{1}{\sqrt{1-x^2}} - 3\sin(3x) - e^x}{\frac{1}{1+(3x)^2} \cdot (3) + 2x - 3\cos(3x)} \quad \left(\frac{0}{0}\right)$$

$$\stackrel{\text{prep}}{=} \lim_{x \rightarrow 0} \frac{(1-x^2)^{-\frac{1}{2}} - 3\sin(3x) - e^x}{3(1+9x^2)^{-1} + 2x - 3\cos(3x)} \quad \left(\frac{0}{0}\right) \quad \stackrel{\text{L'H}}{=} \lim_{x \rightarrow 0} \frac{-\frac{1}{2}(1-x^2)^{-\frac{3}{2}} \cdot (-2x) - 9\cos(3x) - e^x}{-3(1+9x^2)^{-2} \cdot (18x) + 2 + 9\sin(3x)}$$

$$\stackrel{\text{rewrite}}{=} \lim_{x \rightarrow 0} \frac{\frac{x}{(1-x^2)^{\frac{3}{2}}} - 9\cos(3x) - e^x}{\frac{-54x}{(1+9x^2)^2} + 2 + 9\sin(3x)} \quad \begin{matrix} \nearrow 0 \\ \nearrow 1 \\ \nearrow 1 \\ \nearrow 0 \end{matrix} \quad = \frac{-9-1}{2} = \frac{-10}{2} = \boxed{-5}$$

$$\text{Ex: } \lim_{x \rightarrow \infty} \left(1 - \frac{2}{x^3}\right)^{x^3} \stackrel{1^\infty}{=} \lim_{x \rightarrow \infty} e^{\ln\left(\left(1 - \frac{2}{x^3}\right)^{x^3}\right)} \stackrel{\infty \cdot 0}{=} \lim_{x \rightarrow \infty} x^3 \ln\left(1 - \frac{2}{x^3}\right)$$

$$= e \lim_{x \rightarrow \infty} \frac{\ln\left(1 - \frac{2}{x^3}\right)}{\frac{1}{x^3}} \quad \left(\frac{0}{0}\right) \stackrel{\text{L'H}}{=} \lim_{x \rightarrow \infty} \frac{\left(\frac{1}{1 - \frac{2}{x^3}}\right) \left(\frac{6}{x^4}\right)}{-\frac{3}{x^4}}$$

$$= e \lim_{x \rightarrow \infty} \left(\frac{1}{1 - \frac{2}{x^3}}\right) \left(\frac{6}{x^4}\right) \cdot \left(-\frac{x^4}{3}\right) = e \lim_{x \rightarrow \infty} \left(\frac{1}{1 - \frac{2}{x^3}}\right) \cdot (-2) \quad \begin{matrix} \nearrow 0 \\ \nearrow 0 \end{matrix} \quad = e^{1 \cdot (-2)} = \boxed{e^{-2}}$$

Continue to NEXT Page for HW problems.

Compute each of the following Limits. Simplify. *Justify every step.*

$$1. \lim_{\theta \rightarrow \frac{\pi}{2}} \frac{1 - \sin \theta}{1 + \cos(2\theta)}$$

$$2. \lim_{x \rightarrow \infty} \frac{\ln x}{\sqrt{x}}$$

$$3. \lim_{x \rightarrow 0^+} \frac{\ln x}{x}$$

$$4. \lim_{x \rightarrow 0} \frac{e^{2x} - 1 - 2x}{x^2}$$

$$5. \lim_{x \rightarrow 0} \frac{\sin x - x}{x^3}$$

$$6. \lim_{x \rightarrow 0} \frac{e^x - e^{-x} - 2x}{x - \sin x}$$

$$7. \lim_{x \rightarrow 0} \frac{\arcsin(3x)}{\arctan(4x)}$$

$$8. \lim_{x \rightarrow 0} \frac{x - \arcsin x}{\arctan(2x) - 2x}$$

$$9. \lim_{x \rightarrow 0} \frac{3xe^x - \arctan(3x)}{x + \ln(1 - x)}$$

$$10. \lim_{x \rightarrow 0} \frac{\arcsin x + x^2 - x}{\cos x - \arctan(5x) - e^{-5x}}$$

$$11. \lim_{x \rightarrow \infty} x \sin\left(\frac{\pi}{x}\right)$$

$$12. \lim_{x \rightarrow \infty} x \ln\left(1 - \frac{1}{x}\right)$$

$$13. \lim_{x \rightarrow 0^+} x \ln x$$

$$14. \lim_{x \rightarrow 0^+} \sqrt{x} \ln x$$

$$15. \lim_{x \rightarrow \infty} x^2 e^{-x}$$

$$16. \lim_{x \rightarrow \infty} \left(1 + \frac{1}{x}\right)^x$$

$$17. \lim_{x \rightarrow 0^+} (1 + \ln(1 - 3x))^{\frac{1}{x}}$$

$$18. \lim_{x \rightarrow \infty} \left(1 - \arctan\left(\frac{7}{x^4}\right)\right)^{x^4}$$

REGULAR OFFICE HOURS

Monday: 12:00–3:00 pm

6:00–7:30 pm TA Gretta, SMUDD 208

Tuesday: 1:00–4:00 pm

7:30–9:00 pm TA Aidee, SMUDD 208

9–10:30 pm TA Natalie, SMUDD 208

Wednesday: 1:00-3:00 pm

7:30–9:00 pm TA Gretta, SMUDD 208

Thursday: none for Professor

7:30–9:00 pm TA Aidee, SMUDD 208

9:00–10:30 pm TA Natalie, SMUDD 208

Friday: 12:00–2:00 pm

Please e-mail with questions/concerns: dbenedetto@amherst.edu

Start early. Box your answers.

Show all details and justifications in a nice final draft. No Mess.