

## MATH 2250 PRACTICE SHEET FOR FINAL EXAM

1. Use the definition of the derivative to find the derivative of the function

$$f(x) = x^2 + \frac{1}{x}$$

2. Find an equation for the tangent line to the graph of the function

$$f(x) = 3x + \ln x$$

at  $x = 1$ .

Use this information to approximate  $f(1.2)$ .

3. Find the derivative of the function

$$f(x) = \frac{xe^x - 1}{\ln x} \quad \approx \quad \frac{(\ln x)(xe^x + e^x) - (xe^x - 1)\frac{1}{x}}{(\ln x)^2}$$

4. Solve for  $\frac{dx}{dt}$  given the equation

$$\ln(x + y) = e^x - t$$

5. Compute the following limit

$$\lim_{x \rightarrow 0} \frac{\sin x^2}{\cos x - 1}$$

6. Compute the following limit

$$\lim_{x \rightarrow 3} \frac{e^x - e^3}{x - 3}$$

7. Compute the following limit

$$\lim_{x \rightarrow 3} \frac{e^x - e^3}{x}$$

8. Find the absolute minimum and maximum values of the function  $f(x) = x + \ln x$  on the interval  $[1, e]$ .

9. Does the following function have an absolute maximum or absolute minimum value on the interval  $[\frac{1}{2}, \infty)$ ?

$$f(x) = x - 7 \ln x$$

10. Consider the function  $f(x) = \frac{3}{1+x^3}$ , and suppose that  $F(x)$  is an antiderivative for  $f(x)$  with  $F(0) = 0$ .

Explain why  $F(x) = \int_0^x \frac{3}{1+t^3} dt$

11. Two people start walking from the same point, person  $A$  walking due north and person  $B$  walking due east. After some time, if person  $A$  is 40 feet from the starting point and walking at 3 feet per second, and if person  $B$  is 30 feet from the starting point and walking at 5 feet per second, how fast is the distance between the two people changing?

12. Compute

$$\int e^x \cos e^x dx$$

13. Compute

$$\int (\sin x)^7 (\cos x) dx$$

14. Compute

$$\int_0^1 x \sqrt{1-x^2} dx$$

15. Compute

$$\int_0^1 \sqrt{1-x^2} dx$$

*hint: this is a trick question*

16. Compute

$$\int \tan x dx$$

(you shouldn't need to memorize this formula — use  $u$ -substitution!)

17. Find two number  $a$  and  $b$  such that  $3a + 4b = 9$  and such that  $ab$  is as large as possible.

18. Find all critical values of the following functions  $x, x^{-1}, x^2, x^3, x^{2/3}, x^{-2/3}, x + \ln x$ .

Which of these critical values represent local minimums and which represent local maximums?

19. Use Riemann Sums with 3 rectangles and using left endpoints to approximate the value of the integral:

$$\int_0^1 \frac{1}{1+x^3} dx$$

20. Use Riemann Sums and limits to find the value of the definite integral:

$$\int_2^3 (3x+2) dx$$

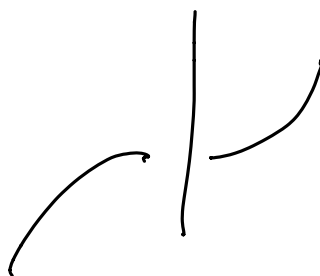
21. A company would like to design a box (bottom, top and four sides), with square base with a volume of exactly 1000 cubic centimeters. How tall should the box be made so that it uses the least amount of material (surface area)?

22. Suppose that  $f(x)$  is defined on  $[-3, 3]$  which satisfies the following properties:

- $f(x)$  is increasing on the interval  $[-3, 0]$ ,
- $f(x)$  is decreasing on  $[0, 3]$ ,
- $f(x)$  is concave down on  $[-3, 1]$ , and
- $f(x)$  is concave up on  $[1, 3]$ .

Use this information to sketch the graph of  $f(x)$ .

23. Sketch a graph of a function which is increasing everywhere, concave down for  $x < 0$  and concave up for  $x > 0$ .



on

$$\ln(x+y) = e^x - t \quad \frac{dx}{dt}$$

$\downarrow d/dt$

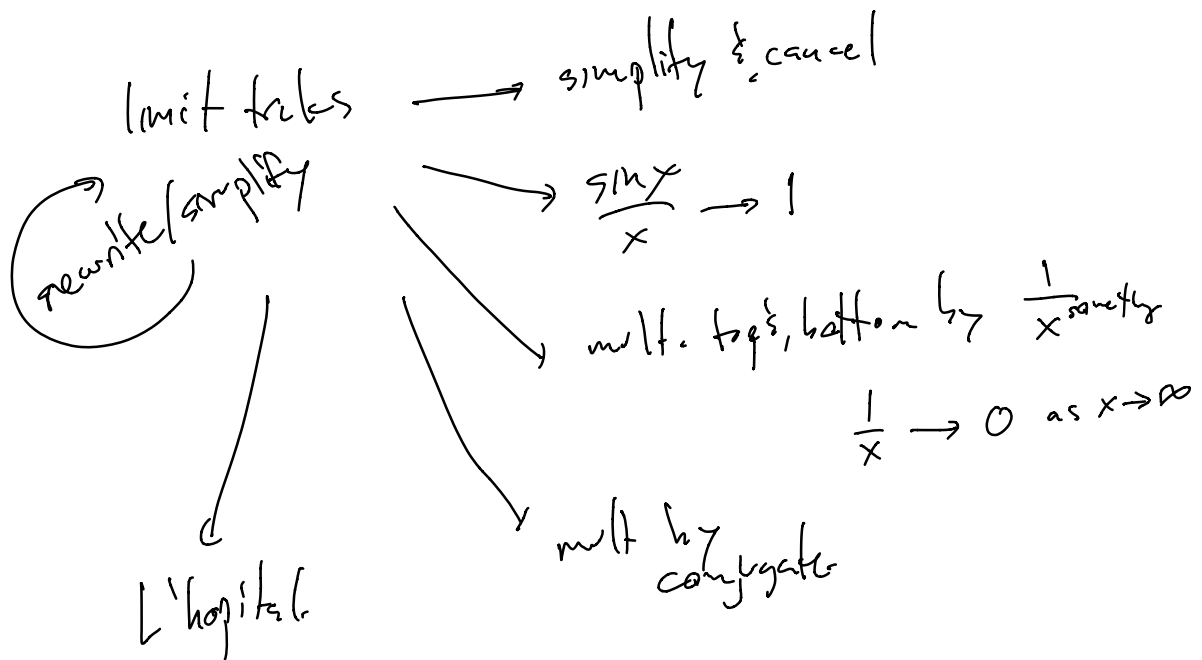
$$\left(\frac{1}{x+y}\right) \left(\frac{dx}{dt} + \frac{dy}{dt}\right) = e^x \frac{dx}{dt} - 1$$

$$\left(\frac{1}{x+y}\right) \frac{dx}{dt} + \left(\frac{1}{x+y}\right) \frac{dy}{dt} = e^x \frac{dx}{dt} - 1$$

$$\left(\frac{1}{x+y}\right) \frac{dx}{dt} - e^x \frac{dx}{dt} = -1 - \frac{1}{x+y}$$

$$\frac{dx}{dt} \left[ \frac{1}{x+y} - e^x \right] = -1 - \frac{1}{x+y}$$

$$\frac{dx}{dt} = \frac{\left(-1 - \frac{1}{x+y}\right)}{\left(\frac{1}{x+y} - e^x\right)}$$



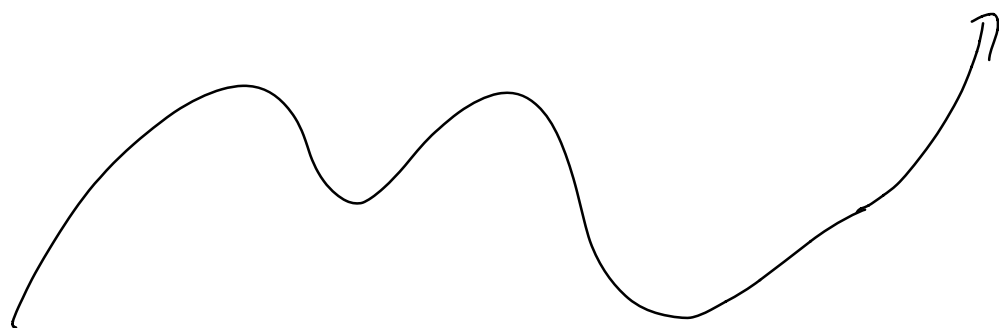
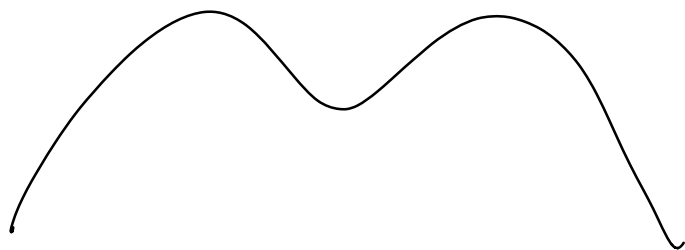
Find two number  $a$  and  $b$  such that  $3a + 4b = 9$  and such that  $ab$  is as large as possible.

get rid of a variable

$$f = ab$$

$$b = \frac{9-3a}{4}$$

$$f(a) = a \left( \frac{9-3a}{4} \right)$$



$$x^2 + y^2 + z^2 + w^2 \quad \text{4 squares theorem}$$

$x, y$  integers

$$x^2 + 3y^2 + 4z^2 + 7w^2$$

$$2x^2 + 2y^2 + 2z^2 + 2w^2$$

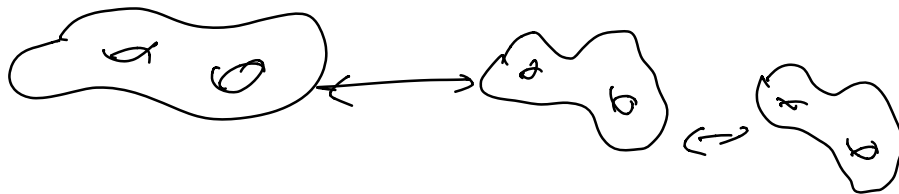
$$9x^2 - 13y^2 + 2z^2 + 7w^2 = \frac{32}{5}$$

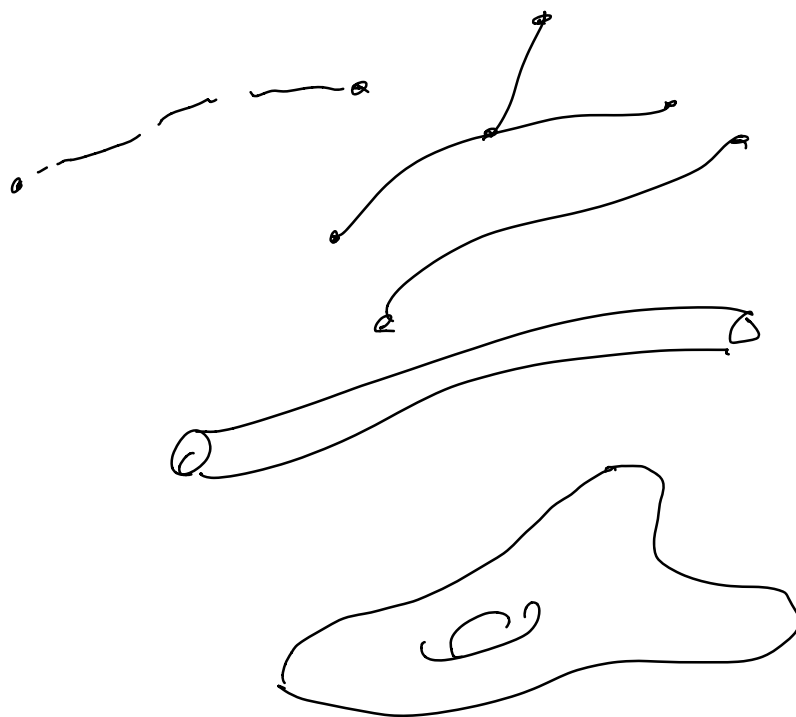
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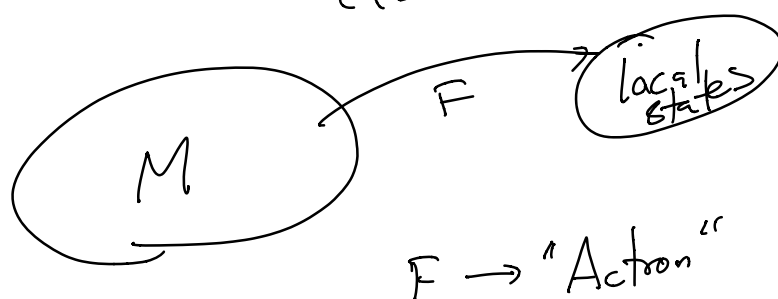
8

$$1 + 2^3 + 2^7 + 2^9 + 2^{13} + 2^{17}$$





"classical field theory"



space states

evolve / time



→ ~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ ~~8~~ ~~9~~ ~~10~~ ~~11~~ ~~12~~ ~~13~~ ~~14~~ ~~15~~ ~~16~~ ~~17~~ ~~18~~ ~~19~~ ~~20~~ ~~21~~ ~~22~~ ~~23~~ ~~24~~ ~~25~~ ~~26~~ ~~27~~ ~~28~~ ~~29~~ ~~30~~ ~~31~~ ~~32~~ ~~33~~ ~~34~~ ~~35~~ ~~36~~ ~~37~~ ~~38~~ ~~39~~ ~~40~~ ~~41~~ ~~42~~ ~~43~~ ~~44~~ ~~45~~ ~~46~~ ~~47~~ ~~48~~ ~~49~~ ~~50~~ ~~51~~ ~~52~~ ~~53~~ ~~54~~ ~~55~~ ~~56~~ ~~57~~ ~~58~~ ~~59~~ ~~60~~ ~~61~~ ~~62~~ ~~63~~ ~~64~~ ~~65~~ ~~66~~ ~~67~~ ~~68~~ ~~69~~ ~~70~~ ~~71~~ ~~72~~ ~~73~~ ~~74~~ ~~75~~ ~~76~~ ~~77~~ ~~78~~ ~~79~~ ~~80~~ ~~81~~ ~~82~~ ~~83~~ ~~84~~ ~~85~~ ~~86~~ ~~87~~ ~~88~~ ~~89~~ ~~90~~ ~~91~~ ~~92~~ ~~93~~ ~~94~~ ~~95~~ ~~96~~ ~~97~~ ~~98~~ ~~99~~ ~~100~~ ~~101~~ ~~102~~ ~~103~~ ~~104~~ ~~105~~ ~~106~~ ~~107~~ ~~108~~ ~~109~~ ~~110~~ ~~111~~ ~~112~~ ~~113~~ ~~114~~ ~~115~~ ~~116~~ ~~117~~ ~~118~~ ~~119~~ ~~120~~ ~~121~~ ~~122~~ ~~123~~ ~~124~~ ~~125~~ ~~126~~ ~~127~~ ~~128~~ ~~129~~ ~~130~~ ~~131~~ ~~132~~ ~~133~~ ~~134~~ ~~135~~ ~~136~~ ~~137~~ ~~138~~ 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$$3 \left[ \frac{1}{2} x^2 + 2x \right]_2^3 = \frac{3}{2} 3^2 + 2(3) - \frac{3}{2} 2^2 - 2 \cdot 2$$

$$= \frac{27}{2} + 6 - 6 - 4$$

$$\frac{27}{2} - \frac{8}{2} = \frac{19}{2}$$

Use Riemann Sums and limits to find the value of the definite integral:

$$\int_2^3 (3x + 2) dx$$

$$a = 2$$

$$b = 3$$

$$n = \# \text{ rect-y's}$$

$$\Delta x = \frac{b-a}{n} = \frac{1}{n}$$



$$x_i^* = a + i \cdot \Delta x$$

$$= 2 + i/n$$

$$\text{ht: } f(x_i) = 3(2 + i/n) + 2$$

$$\text{Area} \approx \Delta x f(x_1) + \Delta x f(x_2) + \dots$$

$$= 6 + 3i/n + 2$$

$$= 8 + 3i/n$$

$$= \sum_{i=1}^n \Delta x f(x_i^*)$$

$$= \sum_{i=1}^n \frac{1}{n} (8 + 3i/n)$$

$$= \frac{1}{n} \sum_{i=1}^n 8 + \frac{3}{n^2} \sum_{i=1}^n i$$

$$= \frac{8n}{n} + \frac{1}{n} \frac{3}{n} \sum_{i=1}^n i$$

$$\underbrace{\sum_{i=1}^n i}_{\frac{n(n+1)}{2}}$$

$$= 8 + \frac{3}{n^2} \left( \frac{n(n+1)}{2} \right)$$

$$= 8 + \frac{3}{2} \frac{(n+1)}{n}$$

$$= 8 + \frac{3}{2} \left( 1 + \frac{1}{n} \right)$$

$$n \rightarrow \infty \Rightarrow 8 + \frac{3}{2} (1) \\ = \frac{19}{2}$$