MARK BOX		
PROBLEM	POINTS	
0A	11	
0B	8	
0C	8	
0D	3	
Total for 0	30	
1	10	
2	10	
3	10	
4-13	40=10x4	
%	100	

HAND IN PART

NAME: ______________________________

PIN: ______________________________

INSTRUCTIONS

- This exam comes in two parts.
  1. HAND IN PART. Hand in only this part.
  2. STATEMENT OF MULTIPLE CHOICE PROBLEMS. Do not hand in this part.
     You can take this part home to learn from and to check your answers once the solutions are posted.
- On Problem 0, fill in the blanks. As you know, if you do not make at least half of the points on Problem 0, then your score for the entire exam will be whatever you made on Problem 0.
- During this exam, do not leave your seat unless you have permission. If you have a question, raise your hand. When you finish: turn your exam over, put your pencil down and raise your hand.
- During the exam, the use of unauthorized materials is prohibited. Unauthorized materials include: books, personal notes, electronic devices, and any device with which you can connect to the internet. Unauthorized materials (including cell phones, as well as your watch) must be in a secured (e.g. zipped up, snapped closed) bag placed completely under your desk or, if you did not bring such a bag, given to Prof. Girardi to hold during the exam (it will be returned when you leave the exam). This means no electronic devices (such as cell phones) allowed in your pockets.
- Cheating is grounds for a F in the course.
- At a student's request, I will project my watch upon the projector screen.
  Upon request, you will be given as much (blank) scratch paper as you need.
- The MARK BOX above indicates the problems along with their points.
  Check that your copy of the exam has all of the problems.
- This exam covers (from *Calculus* by Thomas, 13^{th} ed., ET): §10.7–10.10, 11.1, 11.2 .

Honor Code Statement

I understand that it is the responsibility of every member of the Carolina community to uphold and maintain the University of South Carolina's Honor Code.

As a Carolinian, I certify that I have neither given nor received unauthorized aid on this exam.

I understand that if it is determined that I used any unauthorized assistance or otherwise violated the University's Honor Code then I will receive a failing grade for this course and be referred to the academic Dean and the Office of Academic Integrity for additional disciplinary actions.

Furthermore, I have not only read but will also follow the instructions on the exam.

Signature : ______________________________

0A. Power Series Condsider a (formal) power series

$$h(x) \;=\; \sum_{n=0}^{\infty} a_n \,(x - x_0)^n \;, \tag{0.1}$$

with radius of convergence $R \in [0, \infty]$.

(Here $x_0 \in \mathbb{R}$ is fixed and $\{a_n\}_{n=0}^{\infty}$ is a fixed sequence of real numbers.)

- For this part, answer the 4 questions by circling one and only one choice. Abbreviations: AC for absolutely convergent, CC for conditionally convergent, and DV for divergent.

  (1) For $x = x_0$, the power series $h(x)$ in (0.1)

  a. is always AC b. is always CC c. is always DV

  d. can do anything, i.e., there are examples showing that it can be AC, CC, or DV.

  (2) For $x \in \mathbb{R}$ such that $|x - x_0| < R$, the power series $h(x)$ in (0.1)

  a. is always AC b. is always CC c. is always DV

  d. can do anything, i.e., there are examples showing that it can be AC, CC, or DV.

  (3) For $x \in \mathbb{R}$ such that $|x - x_0| > R$ the power series $h(x)$ in (0.1)

  a. is always AC b. is always CC c. is always DV

  d. can do anything, i.e., there are examples showing that it can be AC, CC, or DV.

  (4) If $0 < R < \infty$, then for the endpoints $x = x_0 \pm R$, the power series $h(x)$ in (0.1)

  a. is always AC b. is always CC c. is always DV

  d. can do anything, i.e., there are examples showing that it can be AC, CC, or DV.

- For this part, fill in the 7 boxes.

  Let $R > 0$ and donsider the function $y = h(x)$ defined by the power series in (0.1).

  (1) The function $y = h(x)$ is <u>always differentiable</u> on the interval $\boxed{}$ (make this interval as large as it can be, but still keeping the statement true). Furthermore, on this interval

  $$h'(x) \;=\; \sum_{n=\boxed{}}^{\infty} \boxed{} \,. \tag{0.2}$$

  What can you say about the radius of convergence of the power series in (0.2)?

  $\boxed{}$

  (2) The function $y = h(x)$ <u>always has an antiderivative</u> on the interval $\boxed{}$ (make this interval as large as it can be, but still keeping the statement true). Futhermore, if α and β are in this interval, then

  $$\int_{x=\alpha}^{x=\beta} h(x)\,dx \;=\; \sum_{n=\boxed{}}^{\infty} \boxed{} \Bigg|_{\mathbf{x}=\alpha}^{\mathbf{x}=\beta} .$$

0B. Taylor/Maclaurin Polynomials and Series.

For this part, fill-in the 9 boxes.

Let $y = f(x)$ be a function with derivatives of all orders in an interval I containing x_0.

Let $y = P_N(x)$ be the N^{th}-order Taylor polynomial of $y = f(x)$ about x_0.

Let $y = R_N(x)$ be the N^{th}-order Taylor remainder of $y = f(x)$ about x_0.

Let $y = P_\infty(x)$ be the Taylor series of $y = f(x)$ about x_0.

Let c_n be the n^{th} Taylor coefficient of $y = f(x)$ about x_0.

a. The formula for c_n is

$c_n =$ [ ]

b. In open form (i.e., with ... and without a $\sum$-sign)

$P_N(x) =$ [ ]

c. In closed form (i.e., with a $\sum$-sign and without ...)

$P_N(x) =$ [ ]

d. In open form (i.e., with ... and without a $\sum$-sign)

$P_\infty(x) =$ [ ]

e. In closed form (i.e., with a $\sum$-sign and without ...)

$P_\infty(x) =$ [ ]

f. We know that $f(x) = P_N(x) + R_N(x)$. Taylor's BIG Theorem tells us that, for each $x \in I$,

$R_N(x) =$ [ ] for some c [ ].

g. A Maclaurin series is a Taylor series with the center specifically specified as $x_0 =$ [ ].

0C. Commonly Used Taylor Series

Fill in the blank boxes with the choices a – ℓ, which are provided below.
You may use a choice more than once or not at all.
Sample questions, which are needed later in the exam, are already done for you.

a. $\sum_{n=0}^{\infty} x^n$ **d.** $\sum_{n=0}^{\infty} (-1)^n \frac{x^{2n}}{(2n)!}$ **g.** $x \in \mathbb{R}$ **j.** $(-1, 1]$

b. $\sum_{n=0}^{\infty} \frac{x^n}{n!}$ **e.** $\sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{(2n+1)!}$ **h.** $(-1, 1)$ **k.** $[-1, 1)$

c. $\sum_{n=1}^{\infty} (-1)^{n+1} \frac{x^n}{n}$ **f.** $\sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$ **i.** $[-1, 1]$ **ℓ.** none of the others

sample. A power series expansion for $y = \frac{1}{1-x}$ is [a] and is valid precisely when [h].

sample. A power series expansion for $y = e^x$ is [b] and is valid precisely when [g].

0.1. A power series expansion for $y = \cos x$ is [ ] and is valid precisely when [ ].

0.2. A power series expansion for $y = \sin x$ is [ ] and is valid precisely when [ ].

0.3. A power series expansion for $y = \ln(1 + x)$ is [ ] and is valid precisely when [ ].

0.4. A power series expansion for $y = \tan^{-1} x$ is [ ] and is valid precisely when [ ].

0D. Parametric Curves In this part, fill in the 3 boxes. Consider the curve $\mathcal{C}$ parameterized by

$$x = x(t)$$
$$y = y(t)$$

for $a \leq t \leq b$.

1) Express $\frac{dy}{dx}$ in terms of derivatives with respect to t. Answer: $\frac{dy}{dx} =$ [ ]

2) The tangent line to $\mathcal{C}$ when $t = t_0$ is $y = mx + b$ where m is [ ] evaluated at $t = t_0$.

3) The arc length of $\mathcal{C}$, expressed as on integral with respect to t, is

Arc Length = [ ]

On the by-hand problems: 1, 2, and 3,
justify your answer **below** the box and then put your answer **in** the box.
Show all your work neatly and concisely. Explain your thoughts.
You will be graded on the quality and correctness of your justification.

1. Consider the formal power series

$$\sum_{n=1}^{\infty} \frac{(2x+8)^n}{n} \, .$$

As we did in class, in the box below draw a diagram indicating for which x's this series is: absolutely convergent, conditionally convergent, and divergent. Of course, indicate your reasoning. Don't forget to check the endpoints, if there are any.

2. Hint: $e^{x^2} = e^{\left(x^2\right)}$.

2.1. Using a *Commonly Used Taylor Series* (see probelm **0C**), find a power series representation, centered about $x_0 = 0$, for the function

$$f(x) = e^{x^2} \tag{2.1}$$

and say when it is valid.
Express your series in **CLOSED** form (i.e., with a $\sum$-sign and without $\ldots$).

Soln: $e^{x^2} =$ [ ] , valid when [ ]

2.2. Using your solution for first part of this problem, find a power series representation, centered about $x_0 = 0$, for

$$\int e^{x^2}\, dx. \tag{2.2}$$

Express your series in **CLOSED** form (i.e., with a $\sum$-sign and without $\ldots$).
Note: we cannot express $\int e^{x^2}\, dx$. as an elementary function (loosely speaking, you cannot integrate e^{x^2}).

Soln: $\int e^{x^2}\, dx =$ [ ] + C

3. Hint: $\sqrt{e} = e^{\frac{1}{2}}$.

3.1. Using a *Commonly Used Taylor Series* (see probelm **0C**), express the number

$$\sqrt{e} \tag{3.1}$$

as a numerical series. Express your series in **CLOSED** form (i.e., with a $\sum$-sign and without $\dots$).

Soln: $\sqrt{e} =$ [ ]

3.2. In the first part of this problem, you found a_n's so that $\sqrt{e} = \sum_{n=0}^{\infty} a_n$. Now estimate the error in approximating $\sqrt{e}$ by the partial sum $\sum_{n=0}^{2} a_n$ of your infinite series $\sum_{n=0}^{\infty} a_n$ in Part **3.1**.

answer: $\left| \sqrt{e} - \sum_{n=0}^{2} a_n \right| \leq$

MULTIPLE CHOICE PROBLEMS

The statement of the multiple choice problems, along with the scoring, can be found in the STATEMENT OF MULTIPLE CHOICE PROBLEMS portion of the exam.

Table for Multiple Choice Solutions								Do Not Write Below			
PROBLEM							# of sol'ns circled	1	2	B	x
4	4a	4b	4c	4d	4e						
5	5a	5b	5c	5d	5e						
6	6a	6b	6c	6d	6e						
7	7a	7b	7c	7d	7e						
8	8a	8b	8c	8d	8e						
9	9a	9b	9c	9d	9e						
10	10a	10b	10c	10d	10e						
11	11a	11b	11c	11d	11e						
12	12a	12b	12c	12d	12e						
13	13a	13b	13c	13d	13e						
Fill in the "number of solutions circled" column with: 0, 1, or 2.											
								4	1	0	0

STATEMENT OF MULTIPLE CHOICE PROBLEMS
This portion of the exam is **NOT** collected.
Thus you do not have to show your work.

Instructions:

- **When you initially work through the Multiple Choice Problems**, indicate your answers directly on the STATEMENT OF MULTIPLE CHOICE PROBLEMS portion of the exam, which is not collected.
- **After you have finished working all of the Multiple Choice Problems**, circle your answers in the TABLE FOR MULTIPLE CHOICE SOLUTIONS, which is collected.
- You may choice up to **2** answers for each multiple choice problem. The scoring is as follows.
  - ∗ For a problem with precisely one answer marked and the answer is correct, 4 points.
  - ∗ For a problem with precisely two answers marked, one of which is correct, 1 points.
  - ∗ All other cases, 0 points.

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4. Let the function $y = f(x)$ have a power series power series representation $\sum_{n=0}^{\infty} c_n x^n$, which is valid in some interval $(-R, R)$ where $R > 0$.

a. Then $f(0)$ must be 0.

b. Then $f(0)$ must be c_0.

c. Then $f(0)$ must be c_1.

d. Then we know that $f(0)$ exists but we do not know what the value of $f(0)$ is.

e. None of the others.

5. Let the function $y = f(x)$ have a power series power series representation $\sum_{n=0}^{\infty} a_n x^n$, which is valid in some interval J containing 0 and the raduis of J striclty positive. Consider the two statements:
(A) If $y = f(x)$ is an even function (i.e., $f(-x) = f(x)$), then $a_1 = a_3 = a_5 = \cdots = 0$.
(B) If $y = f(x)$ is an odd function (i.e., $f(-x) = -f(x)$), then $a_0 = a_2 = a_4 = \cdots = 0$.

a. Both (A) and (B) are true.

b. Both (A) and (B) are false.

c. (A) is true but (B) is false.

d. (A) is false but (B) is true.

e. None of the others.

►. **Problems 4 and 5 were meant to help you with Problem 0C.** ☺☺☺

6. Find the interval of convergence of the power series

$$\sum_{n=1}^{\infty} \frac{(x-2)^n}{10^n}$$

Recall that the interval of convergence is the set of x's for which the power series converges, either absolutely or conditionally.

a. $(-10, 10)$

b. $[-10, 10]$

c. $(-8, 12)$

d. $[-8, 12]$

e. None of the others.

7. Find the 3rd order Taylor polynomial, about the center $x_0 = 1$, for the function $f(x) = x^5 - x^2 + 5$.

a. $p_3(x) = 5 + 3(x-1) + 9(x-1)^2 + 10(x-1)^3$

b. $p_3(x) = 5 + 3(x-1) + 18(x-1)^2 + 60(x-1)^3$

c. $p_3(x) = 5 + 3x + 9x^2 + 10x^3$

d. $p_3(x) = 5 + 3x + 18x^2 + 60x^3$

e. None of the others.

8. Using the geometric series, find a power series representation about (i.e., centered at) $x_0 = 5$ for the function

$$g(x) = \frac{3}{x-2}$$

and indicate when the representation is valid.

a. $\displaystyle\sum_{n=0}^{\infty} \left(\frac{-1}{3}\right)^n (x-5)^n$, valid on $(2, 8)$.

b. $\displaystyle\sum_{n=0}^{\infty} \left(\frac{1}{3}\right)^n (x-5)^n$, valid on $(2, 8)$.

c. $\displaystyle\sum_{n=0}^{\infty} (-1)^n (x-5)^n$, valid on $(4, 6)$.

d. $\displaystyle\sum_{n=0}^{\infty} (x-5)^n$, valid on $(4, 6)$.

e. None of the others.

9. Using a known (commonly used) Taylor series, find the Taylor series for

$$f(x) = \frac{1}{(1-x)^4}$$

about the center $x_0 = 0$ which is valid for $|x| < 1$. Hint. Start with the Taylor series expansion

$$\frac{1}{1-x} = \sum_{k=0}^{\infty} x^k \qquad \text{valid for } |x| < 1$$

and differentiate (as many times as needed). Be careful and don't forget the chain rule:

$$D_x(1-x)^{-1} = (-1)(1-x)^{-2}\, D_x(1-x) = (-1)(1-x)^{-2}\,(-1) = (1-x)^{-2}\ .$$

a. $\displaystyle\sum_{n=0}^{\infty} \frac{(n)(n-1)(n-2)}{6}\, x^{n-3}$

b. $\displaystyle\sum_{n=0}^{\infty} (n)(n-1)(n-2)\, x^n$

c. $\displaystyle\sum_{n=0}^{\infty} \frac{(n+3)(n+2)(n+1)}{6}\, x^n$

d. $\displaystyle\sum_{n=0}^{\infty} (-1)^n\, \frac{(n+3)(n+2)(n+1)}{6}\, x^n$

e. None of the others.

10. Find a parameterization for the line segment from $(-1, 2)$ to $(10, -6)$ for $0 \le t \le 1$.

a. $x = 10 - 8t$ and $y = -1 + t$

b. $x = -1 + 11t$ and $y = 2 - 8t$

c. $x = -1 + 11t$ and $y = -6 - 8t$

d. $x = -1 - 11t$ and $y = -8t$

e. None of the others.

11. A parametrization of a circle with center at $(0, 0)$ and radius 1, which is traced out twice in the clockwise direction is

a. $x(t) = \cos t$ and $y(t) = \sin t$ for $0 \leq t \leq 2\pi$

b. $x(t) = \cos t$ and $y(t) = \sin t$ for $0 \leq t \leq 4\pi$

c. $x(t) = \cos t$ and $y(t) = -\sin t$ for $0 \leq t \leq 2\pi$

d. $x(t) = \cos t$ and $y(t) = -\sin t$ for $0 \leq t \leq 4\pi$

e. None of the others.

12. Find an equation for the line tangent to the curve parameterized by

$$x = 2t^2 + 3$$
$$y = t^4$$

at the point defined by the value $t = -1$.

a. $y = x - 6$

b. $y = x - 4$

c. $y = -x - 6$

d. $y = -x - 4$

e. None of the others.

13. Find the Cartesian coordinates of the point with polar coordinates

$$\left(-3, \frac{5\pi}{6}\right)$$

a. $\left(\frac{3}{2}, -\frac{3\sqrt{3}}{2}\right)$

b. $\left(-\frac{3}{2}, \frac{3\sqrt{3}}{2}\right)$

c. $\left(\frac{3\sqrt{3}}{2}, -\frac{3}{2}\right)$

d. $\left(-\frac{3\sqrt{3}}{2}, \frac{3}{2}\right)$

e. None of the others.