Your name: ____________________________ Your NetID: _______________________

- No notes, books, or electronics out or hats or sunglasses on during the exam.
- For all free response questions, show work that justifies your answer.
- Scratch paper is provided at the end of the exam.
- Continuing to write after time has ended will result in the loss of all points on the pages written on.
- Mark your Discussion Section in the table below: **Failure to correctly mark your section will result in a 1 point deduction.**

<table>
<thead>
<tr>
<th>Discussion Section</th>
<th>Instructor (TA)</th>
<th>Time (Wed,Fri)</th>
<th>Discussion Section</th>
<th>Instructor (TA)</th>
<th>Time (Wed,Fri)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD1</td>
<td>Linz, William</td>
<td>11am</td>
<td>CD1</td>
<td>Christenson, Cassie</td>
<td>9am</td>
</tr>
<tr>
<td>AD2</td>
<td>Pynn-Coates, Nigel</td>
<td>1pm</td>
<td>CD2</td>
<td>Gonzalez, Oscar</td>
<td>1pm</td>
</tr>
<tr>
<td>ADA</td>
<td>Yamzon, Nicole</td>
<td>8am</td>
<td>CD3</td>
<td>Park, Shinhae</td>
<td>9am</td>
</tr>
<tr>
<td>ADB</td>
<td>Yamzon, Nicole</td>
<td>9am</td>
<td>CDA</td>
<td>Kundu, Abhra</td>
<td>8am</td>
</tr>
<tr>
<td>ADC</td>
<td>Mendes de Araujo, Pedro</td>
<td>10am</td>
<td>CDB</td>
<td>Kundu, Abhra</td>
<td>9am</td>
</tr>
<tr>
<td>ADD</td>
<td>Yang, Yuji</td>
<td>11am</td>
<td>CDC</td>
<td>Park, Jungsoo</td>
<td>10am</td>
</tr>
<tr>
<td>ADE</td>
<td>Nahvi, Mina</td>
<td>1pm</td>
<td>CDD</td>
<td>Wang, Weihang</td>
<td>11am</td>
</tr>
<tr>
<td>ADF</td>
<td>Nahvi, Mina</td>
<td>2pm</td>
<td>CDE</td>
<td>Balderrama, William</td>
<td>12pm</td>
</tr>
<tr>
<td>ADH</td>
<td>Zhu, Heyi</td>
<td>8am</td>
<td>CDF</td>
<td>Balderrama, William</td>
<td>1pm</td>
</tr>
<tr>
<td>ADI</td>
<td>Zhu, Heyi</td>
<td>9am</td>
<td>CDH</td>
<td>Wu, Qiang</td>
<td>3pm</td>
</tr>
<tr>
<td>ADJ</td>
<td>Folwaczny, Lena</td>
<td>10am</td>
<td>CDJ</td>
<td>Sadoveanu, Vlad</td>
<td>9am</td>
</tr>
<tr>
<td>ADK</td>
<td>Folwaczny, Lena</td>
<td>11am</td>
<td>CDK</td>
<td>Sadoveanu, Vlad</td>
<td>10am</td>
</tr>
<tr>
<td>ADL</td>
<td>Yang, Yuji</td>
<td>12pm</td>
<td>CDL</td>
<td>Park, Jungsoo</td>
<td>11am</td>
</tr>
<tr>
<td>ADM</td>
<td>Mendes de Araujo, Pedro</td>
<td>1pm</td>
<td>CDM</td>
<td>Lee, Chaeryn</td>
<td>1pm</td>
</tr>
<tr>
<td>ADN</td>
<td>Bhardwaj, Neer</td>
<td>3pm</td>
<td>CDN</td>
<td>Wu, Qiang</td>
<td>2pm</td>
</tr>
<tr>
<td>ADO</td>
<td>Bhardwaj, Neer</td>
<td>2pm</td>
<td>CDS</td>
<td>Lee, Chaeryn</td>
<td>12pm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points:</td>
<td>20</td>
<td>10</td>
<td>25</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

Score:
1. (20 points) (5 points each) Evaluate the following limits in (a) - (d). Show sufficient justification for each answer. If the limit does not exist, explicitly state “does not exist”. For infinite limits you must state if it is $\infty$ or $-\infty$. **Do not use L’Hopital’s Rule.**

(a) $\lim_{x \to -\infty} \frac{\sqrt{x^2 + 4}}{4x + 1}$

(b) $\lim_{x \to -2^+} \frac{x + 1}{x^2 - 3x - 10}$

(c) $\lim_{x \to \infty} \sqrt{9x^2 + 4x + 1} - 3x$
(d) \( \lim_{\theta \to 0} \frac{\cos(\theta)}{\theta - 1} \)

2. (10 points) (a) State the limit definition of the derivative of \( f(x) \) as a function.

(b) Using the limit definition of the derivative show the derivative of \( f(x) = 2x^2 - 3x \) is \( f'(x) = 4x - 3 \).
3. (25 points) (5 points each) For each of the functions below, compute the derivative with respect to the indicated variable, using any methods we have covered in class. You do not need to simplify your answers.

(a) \( f(x) = \cos(\pi^2) \ln(\pi)3e^8 \)

(b) \( f(x) = \frac{\arcsin(x)}{x^4 + 1} \)

(c) \( y = (e + 6e^{7x^2})^{\frac{1}{6}} \)
(d) \( y = (\cos(x))^{\cos(x)} \)

(e) Find \( \frac{dy}{dx} \) when \( x^2 - 4xy = 2y + 4 \)

4. (7 points) Find the equation of the tangent line to the curve \( y = \tan \theta \sec \theta \) when \( (\theta, y) = (\pi/4, \sqrt{2}) \).
5. (8 points) Find the equation of each horizontal asymptote for the given function.

\[ f(x) = \frac{10 - e^{2x}}{e^{4x} - 6} \]

6. (8 points) (3/5) This problem is concerned with the Intermediate Value Theorem.

(a) State the Intermediate Value Theorem.

(b) Show that \( f(x) = x^3 - x + 3 \) has a root in the interval \((-10, -1)\).
7. (6 points) Suppose \( \lim_{x \to 1} f(x) = 0 \) and that \( f(x) \) is continuous at \( x = 1 \). Given that
\[
f(x + 2) \leq g(x) \leq 3f(x + 2)
\]
compute the limits below or state that there is not enough information. Be sure to refer to theorems by names and verify hypotheses, if applicable.

1. \( \lim_{x \to -1} g(x) \)

2. \( \lim_{x \to 1} g(x) \)

8. (12 points) Use the given graph of \( f \) to state the value of each quantity, if it exists. (If an answer does not exist, enter DNE).

(a) \( \lim_{x \to 2^-} f(x) \)    (d) \( f(2) \)
(b) \( \lim_{x \to 2^+} f(x) \)    (e) \( \lim_{x \to 4} f(x) \)
(c) \( \lim_{x \to 2} f(x) \)    (f) \( f(4) \)
9. (2 points) The graph of $f(x)$ is shown below. Which of the following could be the graph of the derivative function, $f'(x)$?

![Graph of $f(x)$ and options](image)

10. (2 points) **True** or **False**: If $g(x) = x^5$, then $\lim_{x \to 2} \frac{g(x) - g(2)}{x - 2} = 80$.

11. (1 point) The graph of the function $f(x)$ and its derivative $f'(x)$ are shown. Which is bigger, $f'(-1)$ or $f''(-1)$?
**Scratch Work**