Differentiation Drill
Douglas Meade, Ronda Sanders, and Xian Wu
Department of Mathematics

Overview
This lab uses Maple to help you practice your differentiation skills. Three different user interfaces are introduced.

- The Derivatives tutor takes a user-specified function, finds the first and second derivatives, and plots the function and derivatives on a specified domain.
- The Differentiation Methods tutor shows the step-by-step application of the differentiation rules involved in finding the derivative of a user-specified function.
- The DerivativeDrill maplet allows the user to select types of functions and rules and then generates random problems of this type; the user has to enter the correct derivative. This maplet also provides practice entering mathematical expressions in Maple syntax.

Used properly, these are excellent tools for helping students hone their understanding of derivatives and their differentiation skills.

Maple Essentials
- Important Maple commands introduced in this lab are:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>diff(f(x),x^n)</td>
<td>find nth derivative of f(x)</td>
<td>diff(x^8,x$4);diff(x*cos(x),x$98);</td>
</tr>
<tr>
<td>ln</td>
<td>(natural) logarithm function, ln x</td>
<td>ln(x); ln(2*x-exp(x)); ln(3);</td>
</tr>
<tr>
<td>log</td>
<td>(natural) logarithm function, ln x</td>
<td>log(x); log(2*x-exp(x));log(3);</td>
</tr>
<tr>
<td>log[a]</td>
<td>base a logarithm function, log_a x</td>
<td>log<a href="x">10</a>; log<a href="x">3</a>; log<a href="9">3</a>;</td>
</tr>
</tbody>
</table>

- The Derivatives tutor is started from the Maple 13 user interface under the Tools menu:

  Tools → Tutors → Calculus - Single Variable → Derivatives ...

  Be sure to enter the function correctly and specify a reasonable domain by entering appropriate values in the boxes labeled a = and b =. The Display button displays the first and second derivatives and plots the function and derivatives (make sure boxes below them are checked) on the specified domain. The plot shows how the derivatives can be used to determine the concavity and intervals of increase and decrease. This is a great tool to use when you need to check your answer to a problem in the text.

- The Differentiation Methods tutor is started from the Maple 13 user interface under the Tools menu:

  Tools → Tutors → Calculus - Single Variable → Differentiation Methods ...

  This tutor is designed to help you practice the individual steps involved in finding the derivative of a given function. Do not be afraid to use Get Hint and Next Step — particularly when the hint suggests using the Rewrite rule. Also, you might find it useful to mark the Constant and Constant Multiple rules as being understood (see the Understood Rules menu).

- The DerivativeDrill maplet is available from the course website:


  This maplet generates random differentiation problems using the types of functions and differentiation rules that you select and checks if you correctly find the derivative. Start slowly and build to more complicated expressions as you gain confidence in your differentiation skills.
Related course material/Preparation

§3.1, §3.2, §3.3, §3.4, and §3.6 of the textbook. Prior to the beginning of this lab, be sure you know the basic differentiation rules.

Activities

Here are a few extended questions to get you started.

1. For each of the functions listed below, use the Derivatives tutor to find the first and second derivatives. Plot the function and derivatives on an appropriate window \([a, b] \times [c, d]\). (See the Directions below.) Notice the differences between the original graph and its derivatives. Examine the plot to see how the derivatives can be used to find the inflection points of \(f(x)\) and determine where \(f(x)\) is increasing, decreasing, concave up, and concave down.

(a) \(f(x) = x^2 + 4x - 6\)
(b) \(f(x) = \frac{1}{3}x^3 - x^2 - 3x + 4\)
(c) \(f(x) = 3(x^4 - x^3 - x^2 + x)\)
(d) \(f(x) = \ln(\frac{1}{2})\)
(e) \(f(x) = \frac{1}{\ln x}\)
(f) \(f(x) = \ln(x^2)\)
(g) \(f(x) = (\ln x)^2\)
(h) \(f(x) = x \ln x\)

Directions:

- Launch the Derivatives tutor.
- Enter your function, say, \(x^2 + 4x - 6\) as \(f(x)\) and specify an interval for \(x\), say, \(a = -5\) and \(b = 5\).
- Click on Plot Options.
  - Check Enable user-defined ranges.
  - Change the window ranges to, say, \([-5, 5] \times [-10, 10]\).
  - Click OK.
- Click Display. Check the plot and then go back to Plot Options to adjust the window ranges if needed.
- If you click Close, Maple will return your graph to the worksheet.

2. List the rules (in an order that can be applied) involved in finding the derivatives of each of the following. (Use the Differentiation Methods tutor.)

(a) \(y = x \sin x\)
(b) \(y = \ln(x^3 + 3x^2 + 7)\)
(c) \(y = x \cos^2 x\)
(d) \(y = \frac{x^2 \sin x}{\cos x}\)
(e) \(y = \sin(\cos(x^3))\)

3. Find the third derivative of \(y = xe^x\). What is \(\frac{d^{100}}{dx^{100}} y\)?

4. Use the DerivativeDrill maplet with polynomial, trigonometric, exponential, and logarithmic functions that utilize the power, product, quotient, and chain rules. Start with only one rule per problem. As you gain confidence, allow up to 2 rules in each problem.

Assignment

Complete lab activities and your lab instructor will give other assignment for each section.