**Differentials and Changes along Different Paths**

1. Let us recap some of the properties of differentials. Fill in the missing pieces below:

The general form for a differential in two variables is:

* describes the change of quantity as we take an infinitesimal step (\_\_\_) along the x-direction plus an infinitesimal step (\_\_\_) along the y-direction.
* and are the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of along the x- and y-direction.
* The differential is called *exact*, if:
* If is exact, then the change obtained by summing up *does / does not* depend on the path.
* If is exact, then *can / cannot* be represented as a function.
* The differential is called *inexact*, if:
* If is *in*exact, then the change obtained by summing up *does / does not* depend on the path.
* If is *in*exact, then *can / cannot* be represented as a function.

1. **Critical thinking question:** Can you think of a simple explanation why the sum over an *in*exact differential depends on the path, whereas the sum over an exact differential does not depend on the path? You could, for example, use the following information:

for an *in*exact differential

for an exact differential

*Now we’re going to investigate several differentials for (in)exactness and we’ll calculate changes along different pathways. We’ll use the MoCChA online tool to calculate sums over differentials.*

**Differential #1:**

1. Is this an exact or inexact differential?
2. Do you expect the sum of to depend on the path? Explain your answer.
3. Go to <https://hub-dev.crc.pitt.edu> -> run Chem1000/differentials.ipynb. This notebook calculates by summing up along a path.
   1. Calculate , i.e. the sum over , along the path from to .   
        
        
      Result:
   2. Calculate along the path from to .   
        
        
      Result:
   3. Compare the results for both pathways. Are and equal? Explain your finding.
   4. Repeat (a) and (b) with step size 0.01. Are and equal?

**Differential #2:**

1. Is this an exact or inexact differential?
2. Do you expect the sum of to depend on the path? Explain your answer.
3. Go to <https://hub-dev.crc.pitt.edu> -> run Chem1000/differentials.ipynb. This notebook calculates by summing up along a path.
   1. Calculate , i.e. the sum over , along the path from to . Use a step size of 0.1.  
        
        
      Result:
   2. Calculate along the path from to . Use a step size of 0.1.  
        
        
      Result:
   3. Compare the results for both pathways. Are and equal? Explain your finding.
   4. Repeat (a) and (b) with step size 0.01. Are and equal?

**Differential #3:**

1. Is this an exact or inexact differential?
2. Do you expect the sum of to depend on the path? Explain your answer.
3. Go to <https://hub-dev.crc.pitt.edu> -> run Chem1000/differentials.ipynb. This notebook calculates by summing up along a path.
   1. Calculate , i.e. the sum over , along the path from to . Use a step size of 0.1.  
        
        
      Result:
   2. Calculate along the path from to . Use a step size of 0.1.  
        
        
      Result:
   3. Compare the results for both pathways. Are and equal? Explain your finding.
   4. Repeat (a) and (b) with step size 0.01. Are and equal?

**Differential #4:**

1. Is this an exact or inexact differential?
2. Do you expect the sum of to depend on the path? Explain your answer.
3. Go to <https://hub-dev.crc.pitt.edu> -> run Chem1000/differentials.ipynb. This notebook calculates by summing up along a path.
   1. Calculate , i.e. the sum over , along the path from to . Use a step size of 0.1.  
        
        
      Result:
   2. Calculate along the path from to . Use a step size of 0.1.  
        
        
      Result:
   3. Compare the results for both pathways. Are and equal? Explain your finding.
   4. Repeat (a) and (b) with step size 0.01. Are and equal?