# Algorithm for Integration Using the Trapezoid Rule

We want to calculate using trapezoids, with the heights of the trapezoid given by the left edge **and** the right edge, to some desired precision.

Area of a trapezoid =

**Straightforward (simple but somewhat inefficient) version of the Trapezoid Rule**

Given *left* (or *a* in the notation above), *right* (or *b* in the notation above), *f*(*x*), *precision, maxLoops*

// Start with an initial approximation - in this case, 1 trapezoid

*numParts* 🡨 1

*totalWidth* 🡨 *right* - *left*

*height*1 🡨 *f*(*left*)

*height*2 *🡨 f*(*right*)

*estimate* 🡨 ½ \* (*height*1 + *height*2) \* *totalWidth*

// setup for loop:

*numLoops* 🡨 0

*keepGoing* 🡨 **true**

// While we are not "close enough"

While (*keepGoing*)

Add 1 to *numLoops*

*oldEstimate* 🡨 *estimate*

// Find a better approximation - use twice as many trapezoids

Multiply *numParts* by 2

*currentWidth* 🡨 *totalWidth* / *numParts*

*estimate* 🡨 0

for each trapezoid *i* starting at *i* = 0

// calculate area of current trapezoid and add to total

*currentLeft* 🡨 *left* + *i* \* *currentWidth*

*currentRight* 🡨 *left* + (*i*+1) \* *currentWidth*

*currentHeightLeft* 🡨 *f*(*currentLeft*)

*currentHeightRight 🡨* *f*(*currentRight*)

*currentArea* 🡨 ½ \* (*curentHeightLeft + currentHeightRight*) \* *currentWidth*

Add *currentArea* to *estimate*

// Check if we are "close enough"

*error* 🡨 absolute value of *estimate* - *oldEstimate*

*relError* 🡨 absolute value of *error* / *estimate*

if *relError* ≤ *precision*

*keepGoing* 🡨 **false**

else if *numLoops* ≥ *maxLoops*

indicate error

*keepGoing* 🡨 **false**

return *estimate*

**Efficiencies: *similar to rectangle rule***

* Can take tasks outside of the loop – e.g.

*estimate* 🡨 0

for each trapezoid *i* starting at *i* = 0

// calculate area of current trapezoid and add to total

*currentLeft* 🡨 *left* + *i* \* *currentWidth*

*currentRight* 🡨 *left* + (*i*+1) \* *currentWidth*

*currentHeightLeft* 🡨 *f*(*currentLeft*)

*currentHeightRight 🡨* *f*(*currentRight*)

*currentArea* 🡨 ~~½ \*~~ (*curentHeightLeft + currentHeightRight*) ~~\*~~ *~~currentWidth~~*

Add *currentArea* to *estimate*

Multiply *estimate* by ½ \* *currentWidth*

* Can keep track of previously used heights so that we don’t need to call the function again
  + For trapezoid rule, note which values are used only once (very left and right edges, calculated for the initial estimate) and which values are used twice (right edge of one interval becomes left edge of next – every new height in the inside portion of the area, as calculated in the inner loop)
  + *Preview: Same for Simpson’s rule, except some values are used once, some are used twice, and midpoints of current parts are multiplied by 4 – may need to keep track of heights using two different variables*