CS121 Parallel Computing
Problem Set 7

1. Derivatives of functions can be computed numerically by finite differences. For example, we can write $\frac{df}{dx} \cong \frac{f(x+\Delta x)-f(x)}{\Delta x}$. We can also use higher order finite differences for more accuracy. For example, we can write the third order finite difference

$$\frac{df}{dx} \cong \frac{-f(x-3\Delta x)+9f(x-2\Delta x)-45\,f(x-\Delta x)+45\,f(x+\Delta x)-9f(x+2\Delta x)+f(x+3\Delta x)}{60}$$

See http://web.media.mit.edu/~crtaylor/calculator.html for an explanation of the methodology for deriving such approximations. If we have a multivariate function, partial derivatives for the different coordinates can be computed in a similar way.

Given a 3D function $f(x,y,z)$, design a CUDA kernel to numerically compute the partial derivatives $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$ in some rectangular region of space, using a fourth order partial difference (with up to 9 terms). Be sure to consider performance issues such as memory coalescing or memory bandwidth.