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Answer **all** the questions

1. Let $f(x,y) = 2x^2 + 3xy + y^2 + x + y + 3$.

(a) Calculate $f(0,1)$ and $f(3,-3)$. [2]

(b) Calculate the average rate of change of $f(x,y)$ from $(0,1)$ to $(3,-3)$. [4]

(c) Calculate **grad** f at the point $(0,1)$. [3]

(d) Calculate the rate of change of $f(x,y)$ at $(0,1)$ in the direction towards $(3,-3)$. [4]

(e) Find the direction of the maximum rate of change $f(x,y)$ at $(0,1)$, and the value of the maximum rate of change. [3]

(f) Use the tangent plane approximation to estimate the value of the function at the point $(-0.02, 1.01)$. [3]

(g) Find the value of z at the critical point on the surface $z = f(x,y)$. [3]

(h) Suppose that you are walking on the surface along the path $2x + y = 1$. Find the critical point on this restricted path. [3]