Fluid Kinematics

Q1) Consider steady, incompressible, two-dimensional flow through a converging duct. A simple approximate velocity field for this flow is
\[ \vec{V} = (u, v) = (U_0 - bx) \hat{i} - by \hat{j} \]
where \( U_0 \) is the horizontal speed at \( x = 0 \). Note that this equation ignores viscous effects along the walls but is a reasonable approximation throughout the majority of the flow field. Calculate the material acceleration for fluid particles passing through this duct. Give your answer in two ways: (1) as acceleration components \( a_x \) and \( a_y \) and (2) as acceleration vector \( \vec{a} \)

Q2) Consider the following steady, two-dimensional velocity field:
\[ \vec{V} = (u, v) = (-0.781 - 4.67x) \hat{i} + (-3.54 + 4.67y) \hat{j} \]
Is there a stagnation point in this flow field? If so, where is it?

Q3) Converging duct flow is modelled by the steady, two-dimensional velocity field of Prob.1. The pressure field is given by.
\[ P = P_0 - \frac{\rho}{2} [2U_0 bx + b^2(x^2+y^2)] \]

Q4) Generate an equation for the streamlines for the given velocity field.
\[ \vec{V} = (u, v) = (U_0 - bx) \hat{i} - by \hat{j} \]

Q5) Generate an equation for the pathline for the given velocity field at (1,2,4).
\[ \vec{V} = (u, v, w) = 4x \hat{i} + (5y+3) \hat{j} + 3t^2 \hat{k} \]