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PHYS 432 PS. 3

$$\partial_t \vec{u} + \vec{u}\cdot\nabla\vec{u} = g\sin\alpha\,\hat{y} - g\cos\alpha\,\hat{x} + \nu\nabla^2\vec{u}\,, \qquad \vec{u} = u(x,t)\,\hat{y}$$
$$\partial_t u + u\cancel{\partial_y u} = g\sin\alpha + \nu\,\partial_{xx}u$$

$$f = u + \underbrace{\frac{g\sin\alpha}{2\nu}\left(x^2 - 2Hx\right)}_{\text{steady-state solution}}$$

now
$$\partial_t f = \nu\,\partial_{xx} f = \nu\,\partial_{xx} + g\sin\alpha$$
$$= (\partial_t u - g\sin\alpha) + g\sin\alpha$$
$$= \partial_t f$$

boundary conditions on $f$:
$$f(0,t) = u(0,t) = 0$$
$$\partial_x f(H,0) = \partial_x u(H,0) + \frac{g\sin\alpha}{\nu}\cdot 0 = 0$$

$$\therefore \quad \left.\begin{array}{l} \partial_t f = \nu\,\partial_{xx} f \\ f(0,t) = 0 \\ \partial_x f(H,t) = 0 \end{array}\right\}$$

$$\boxed{u(x,t) = u_{ss}(x) + f(x,t)}$$

I know this

I solve for this