Stokes Second Problem ATP

Stokes apparently had many problems. This Second Problem is identical to the First Problem, except that we replace (2) with \( u(y = 0, t) = U \cos(\omega t) \) — the plate now oscillates. Note that we are interested only in the steady periodic solution: \( u \) behaves as \( \cos(\omega t + \Phi^u) \) in time, where the phase \( \Phi^u \) is independent of \( t \). (The initial condition (4) is thus irrelevant — it washes out.)

In the steady-periodic state the wall shear stress will be of the form

\[
\tau_W = CU^\alpha_1 \rho^\alpha_2 \mu^\alpha_3 \omega^\alpha_4 \cos(\omega t + \Phi^\tau),
\]

(1)

where the phase \( \Phi^\tau \) is independent of \( t \) and \( C \) is a non-dimensional constant. Find the exponents \( \alpha_1, \alpha_2, \alpha_3 \) and \( \alpha_4 \) by dimensional analysis.

**Hint:** (one approach): See Hint for Stokes’ First Problem; make good use of the steady-periodic form of the solution.
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