3) cont'd $\iint_{S_4} F \cdot dS = \iint_D \langle v^2, \sin^2 u, \cos^2 u \rangle \cdot \langle 0, \sin u, \cos u \rangle \, dA$

$= \iint_D \sin^3 u + \cos^3 u \, dA = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \int_1^2 \sin^3 u + \cos^3 u \, dv \, du$

$= 2 \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin^3 u + \cos^3 u \, du = \frac{1}{2} \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 4\sin^3 u + 4\cos^3 u \, du$

$= \frac{1}{2} \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 3\sin u - \sin 3u + 3\cos u + \cos 3u \, du$

$= \frac{1}{2} \left[-3\cos u + \frac{\cos 3u}{3} + 3\sin u + \frac{\sin 3u}{3} \right]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$

$= 3 - \frac{1}{3} = \frac{8}{3}$

$S = S_1 + S_2 + S_3 + S_4 = 0 + 2\pi + 0 + \frac{8}{3} = \boxed{2\pi + \frac{8}{3}}$