

Problem 2.32

[Difficulty: 3]

2.32 Tiny hydrogen bubbles are being used as tracers to visualize a flow. All the bubbles are generated at the origin ($x=0$, $y=0$). The velocity field is unsteady and obeys the equations:

$$\begin{aligned} u &= 1 \text{ m/s} & v &= 2 \text{ m/s} & 0 \leq t < 2 \text{ s} \\ u &= 0 & v &= -1 \text{ m/s} & 0 \leq t \leq 4 \text{ s} \end{aligned}$$

Plot the pathlines of bubbles that leave the origin at $t=0$, 1, 2, 3, and 4 s. Mark the locations of these five bubbles at $t=4$ s. Use a dashed line to indicate the position of a streakline at $t=4$ s.

Solution

The particle starting at $t=3$ s follows the particle starting at $t=2$ s;

The particle starting at $t=4$ s doesn't move!

Pathlines: **Starting at $t=0$** **Starting at $t=1$ s** **Starting at $t=2$ s** **Streakline at $t=4$ s**

t	x	y	x	y	x	y	x	y
0.00	0.00	0.00					2.00	2.00
0.20	0.20	0.40					1.80	1.60
0.40	0.40	0.80					1.60	1.20
0.60	0.60	1.20					1.40	0.80
0.80	0.80	1.60					1.20	0.40
1.00	1.00	2.00	0.00	0.00			1.00	0.00
1.20	1.20	2.40	0.20	0.40			0.80	-0.40
1.40	1.40	2.80	0.40	0.80			0.60	-0.80
1.60	1.60	3.20	0.60	1.20			0.40	-1.20
1.80	1.80	3.60	0.80	1.60			0.20	-1.60
2.00	2.00	4.00	1.00	2.00	0.00	0.00	0.00	-2.00
2.20	2.00	3.80	1.00	1.80	0.00	-0.20	0.00	-1.80
2.40	2.00	3.60	1.00	1.60	0.00	-0.40	0.00	-1.60
2.60	2.00	3.40	1.00	1.40	0.00	-0.60	0.00	-1.40
2.80	2.00	3.20	1.00	1.20	0.00	-0.80	0.00	-1.20
3.00	2.00	3.00	1.00	1.00	0.00	-1.00	0.00	-1.00
3.20	2.00	2.80	1.00	0.80	0.00	-1.20	0.00	-0.80
3.40	2.00	2.60	1.00	0.60	0.00	-1.40	0.00	-0.60
3.60	2.00	2.40	1.00	0.40	0.00	-1.60	0.00	-0.40
3.80	2.00	2.20	1.00	0.20	0.00	-1.80	0.00	-0.20
4.00	2.00	2.00	1.00	0.00	0.00	-2.00	0.00	0.00

