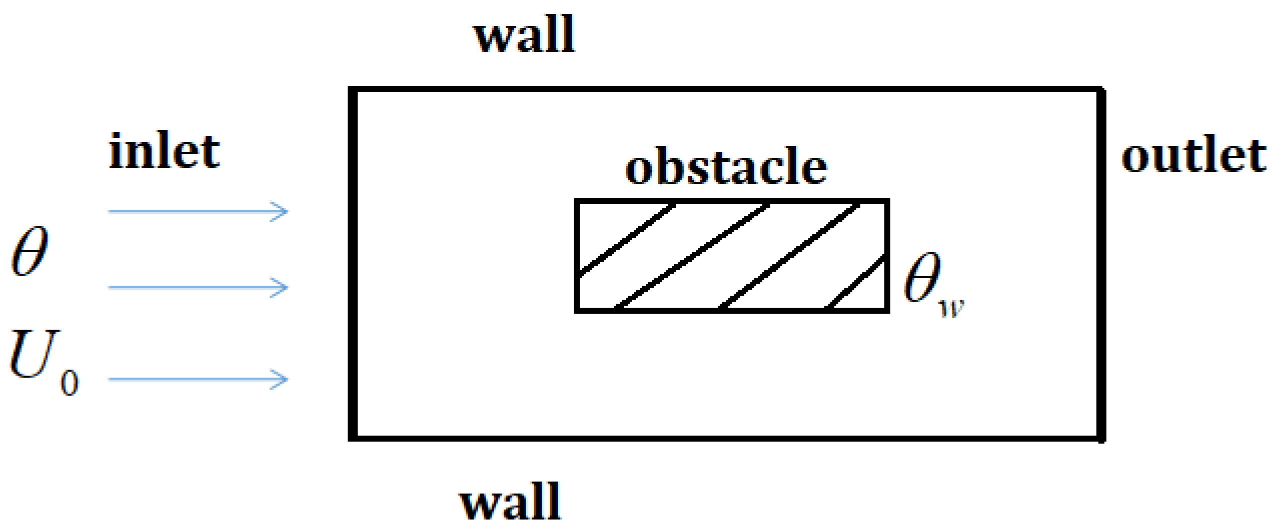
Physical background



Mathematical background

Vorticity - stream function formulation

$$U_x = \frac{\partial \Psi}{\partial y}; U_y = -\frac{\partial \Psi}{\partial x} \qquad \Omega = \frac{\partial U_x}{\partial y} - \frac{\partial U_y}{\partial x}$$

$$\frac{\partial U_x}{\partial x} + \frac{\partial U_y}{\partial y} = 0$$

$$\frac{\partial U_x}{\partial \tau} + U_x \frac{\partial U_x}{\partial x} + U_y \frac{\partial U_x}{\partial y} = -\frac{\partial P}{\partial x} + \frac{1}{\mathrm{Re}}\left(\frac{\partial^2 U_x}{\partial x^2} + \frac{\partial^2 U_x}{\partial y^2}\right)$$

$$\frac{\partial U_y}{\partial \tau} + U_x \frac{\partial U_y}{\partial x} + U_y \frac{\partial U_y}{\partial y} = -\frac{\partial P}{\partial y} + \frac{1}{\mathrm{Re}}\left(\frac{\partial^2 U_y}{\partial x^2} + \frac{\partial^2 U_y}{\partial y^2}\right) + \frac{Gr}{\mathrm{Re}^2}\theta$$

$$\frac{\partial \theta}{\partial \tau} + U_x \frac{\partial \theta}{\partial x} + U_y \frac{\partial \theta}{\partial y} = \frac{1}{\mathrm{Re}\,\mathrm{Pr}}\left(\frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2}\right)$$

Boundary Conditions

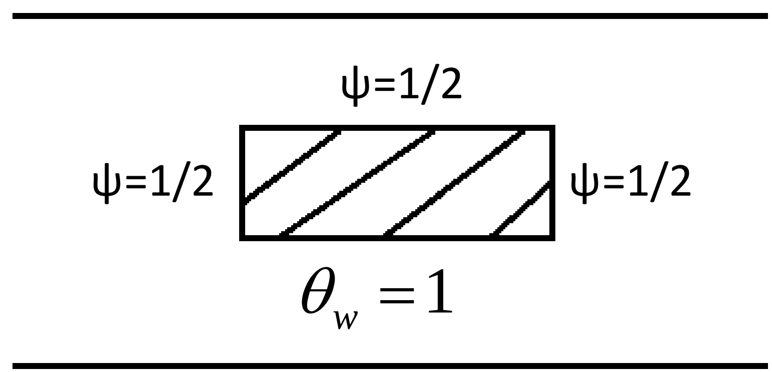
$$\Psi = y_{\max}$$

$$\theta = 0$$

$$U_0 = 1$$

$$\Psi = y \Big|_{0}^{y_{\max}}$$

$$\Omega = 0$$



$$\frac{\partial}{\partial x} = 0$$

$$\Psi = 0$$

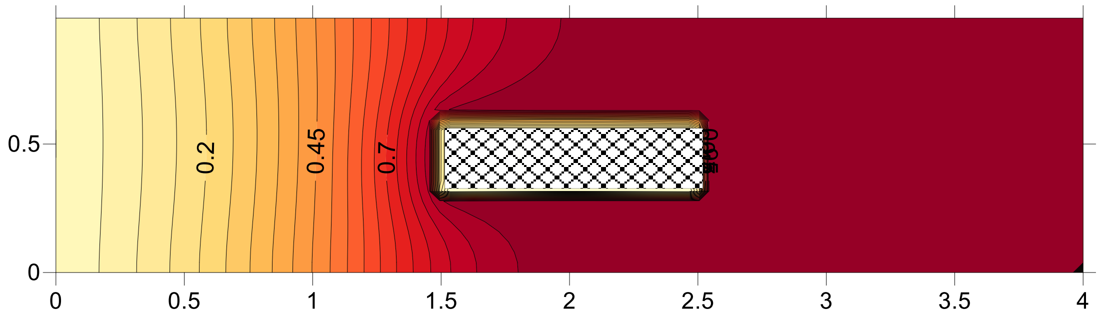
On walls: $\dfrac{\partial \theta}{\partial y} = 0$

$$U = 0$$

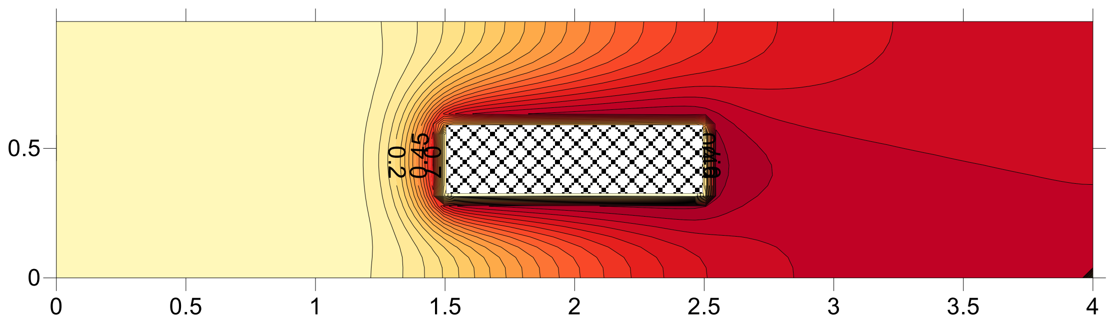
$$\Omega = 2 * \left(\frac{\Psi_{w+1} - \Psi_w}{\Delta y^2} \right)$$

Temperature distribution. Influence of Prandtl number

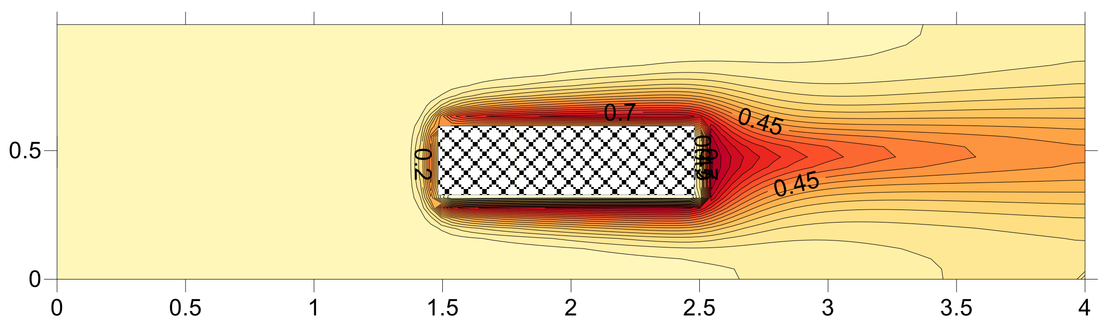
Pr=0.1 Re=10 Gr=0

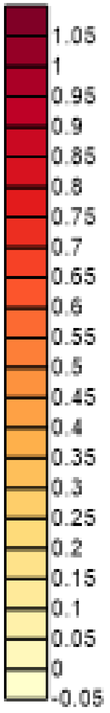


Pr=1 Re=10 Gr=0

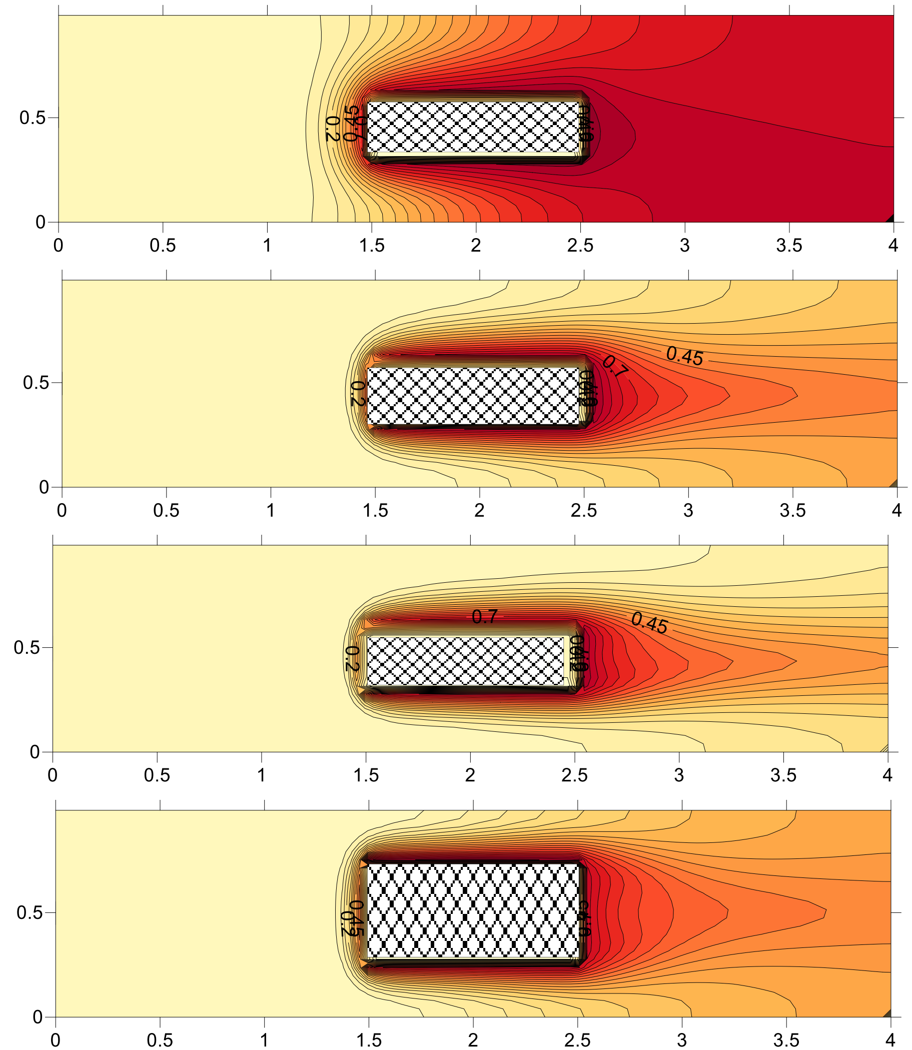


Pr=10 Re=10 Gr=0





Temperature distribution. Influence of Reynolds number

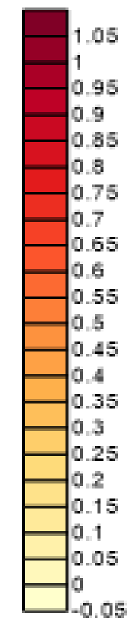


Re=10 Pr=1 Gr=0

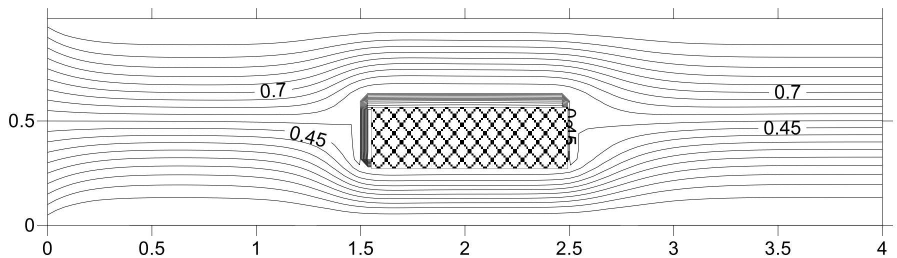
Re=50 Pr=1 Gr=0

Re=100 Pr=1 Gr=0

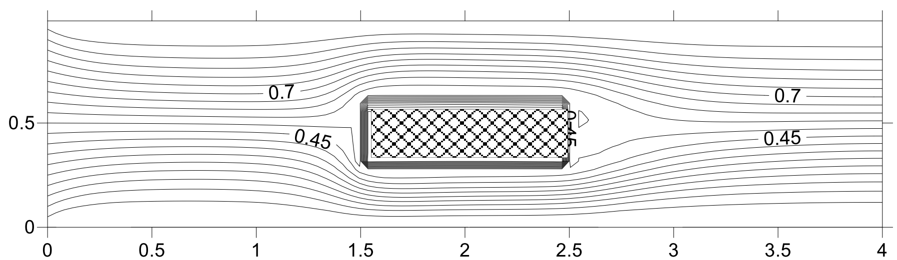
Re=50 Pr=1 Gr=0



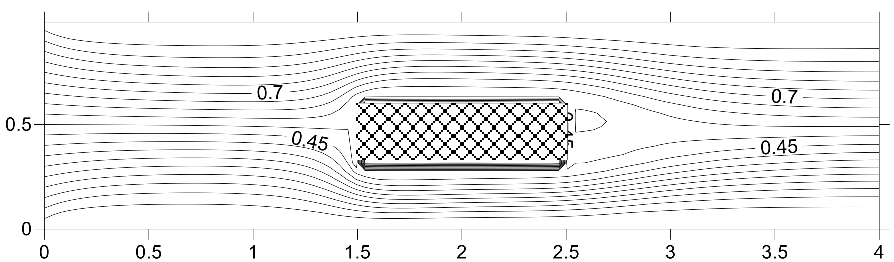
Stream function



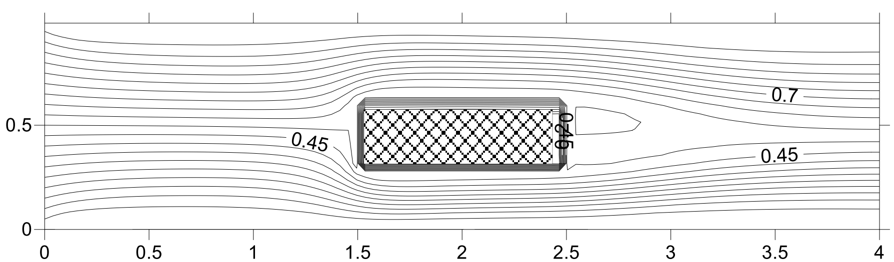
Pr=1 Re=10 Gr=0



Pr=1 Re=50 Gr=0

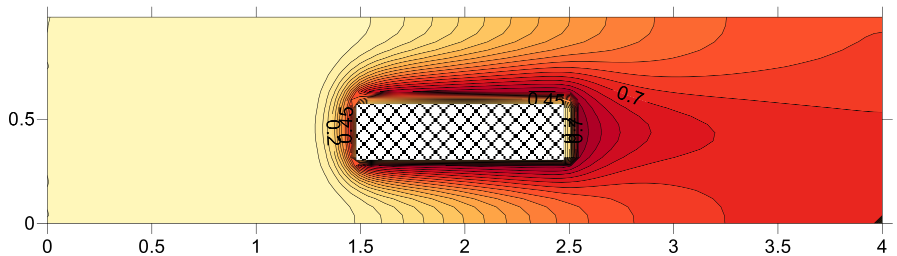


Pr=1 Re=100 Gr=0

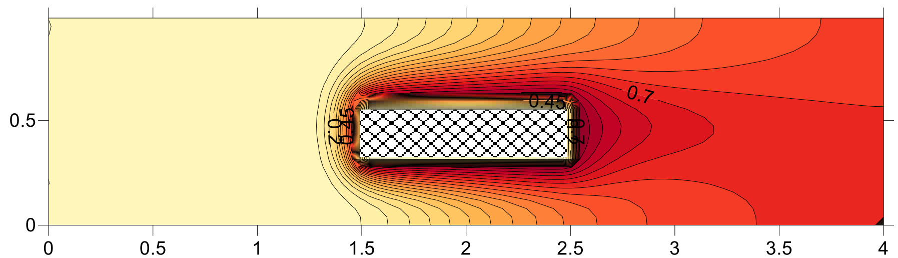


Pr=1 Re=200 Gr=0

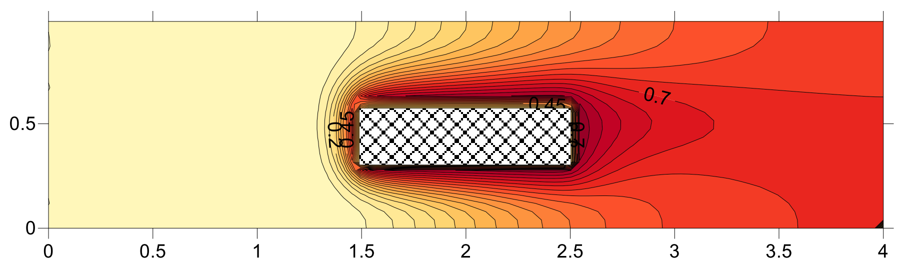
Temperature distribution. Influence of Grashof number



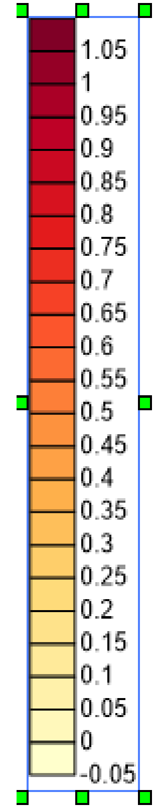
Gr=1000 Pr=0.1 Re=20



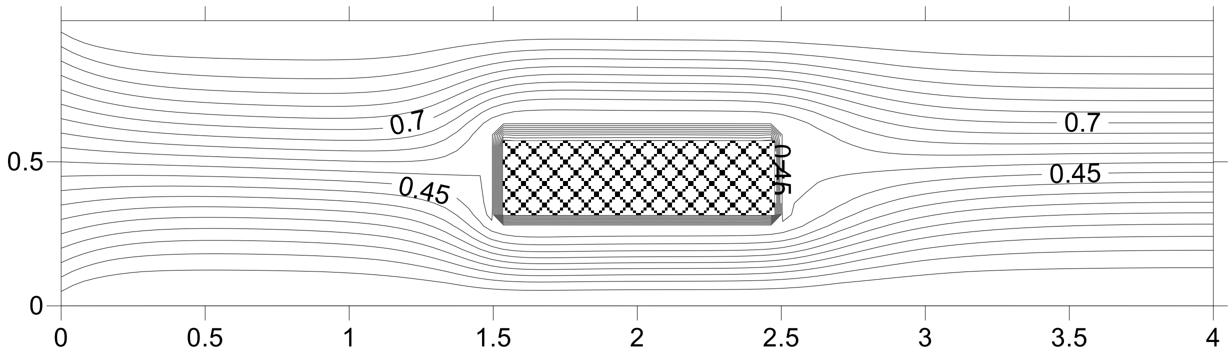
Gr=5000 Pr=0.1 Re=20



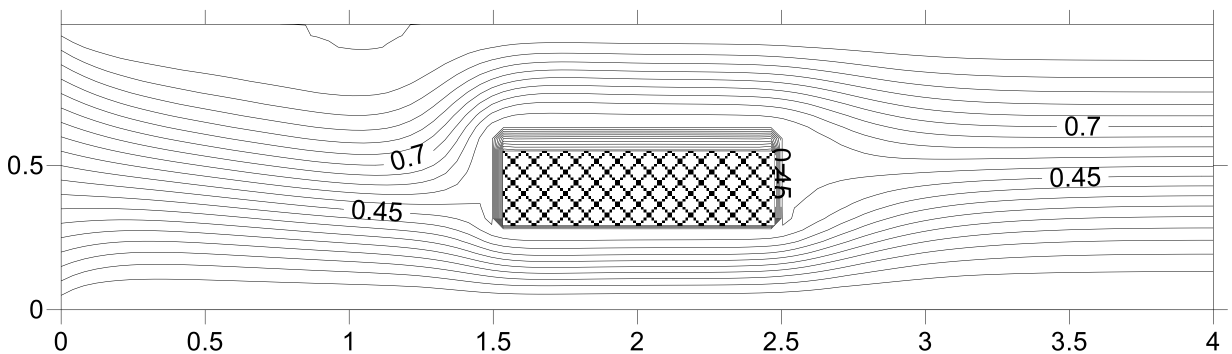
Gr=10000 Pr=0.1 Re=20



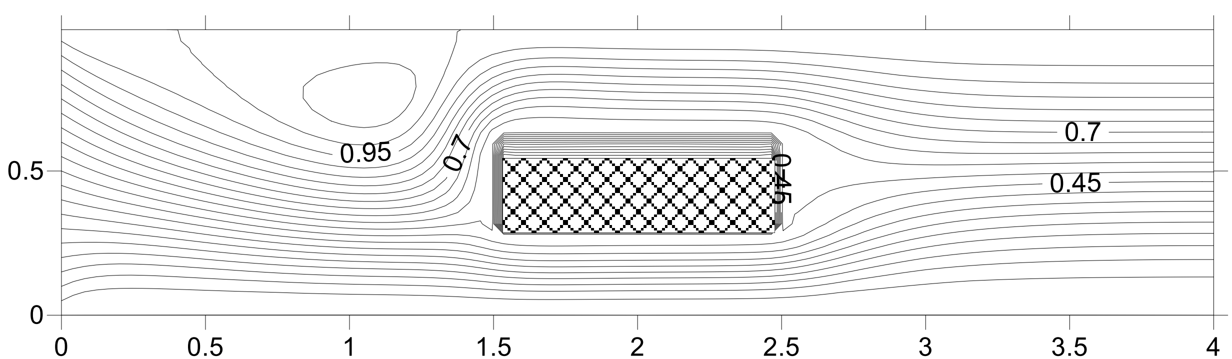
Stream function for different Grashof numbers



Gr=1000 Re=20 Pr=0.1



Gr=5000 Re=20 Pr=0.1



Gr=10000 Re=20 Pr=0.1

Influence of Pr and Re on temperature distribution

$$\frac{i_2 + mx}{2}$$