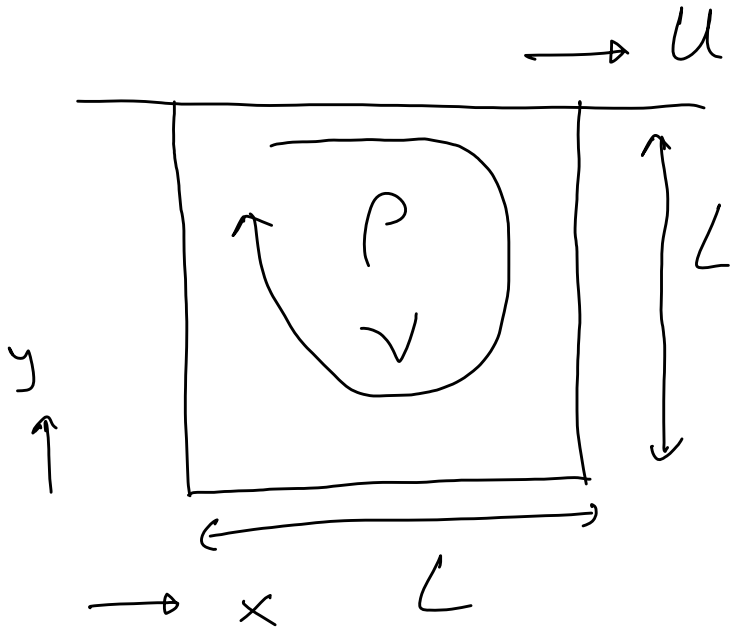


$L = 2\ cm$

$U = 1\ cm/s$

water : $\rho = 10^3\ kg/m^3$

$\nu = 10^{-6}\ m^2/s$

$\vec{u}(x, y, t)$? $\quad Re = \dfrac{UL}{\nu} = 200$

$\tilde{\vec{u}} = \vec{u}/U \quad ; \quad \tilde{x} = \dfrac{x}{L} \quad ; \quad \tilde{y} = \dfrac{y}{L} \quad ; \quad \tilde{t} = tU/L$

$\vec{u}_{LB} \quad U_{LB} \quad \tilde{\vec{u}}_{LB} = \vec{u}_{LB}/U_{LB}$ if $Re = \dfrac{U_{LB} L_{LB}}{\nu_{LB}} = 200$

$U_{LB} = 0.1 \quad Ma_{max} = \dfrac{0.1}{\sqrt{1/3}} = 0.17$

Resolution 20×20 lattice $L_{LB} = 20$

$$\nu_{LB} = \frac{U_{LB} L_{LB}}{Re} = 0.01 \ (lu) \qquad \tau = 3\nu + \frac{1}{2} = 0.53$$

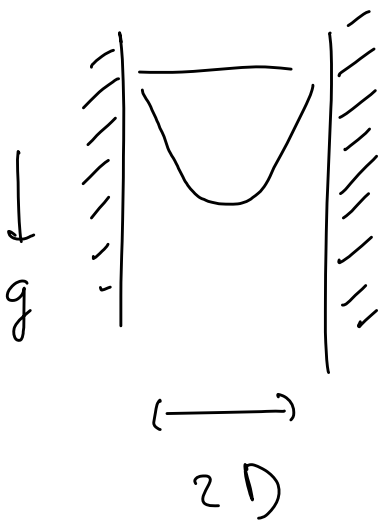
$$\vec{u}_{LB}(\vec{x}, t) \longrightarrow \tilde{\vec{u}}_{LB} = \vec{u}_{LB} / U_{LB} \longrightarrow \vec{u}_{(SI)} = \tilde{\vec{u}}_{LB} U_{SI}$$

Courant number $C = \dfrac{|\vec{u}| \Delta t}{\Delta x} < 1 \qquad \Delta t < \dfrac{\Delta x}{|\vec{u}|} = 0.1 \ s$

$$\Delta t = 1 \ (lu)$$

$$FV \quad \frac{L}{U \Delta t} = \frac{2 \cdot 10^{-2}}{1 \cdot 10^{-2} \ 0.1} = 20$$

$$LB \quad \frac{L}{U \Delta t} = \frac{20}{0.1 \quad 1} = 200$$



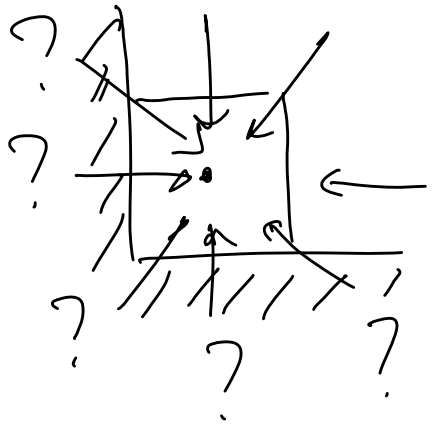
D, g, ν

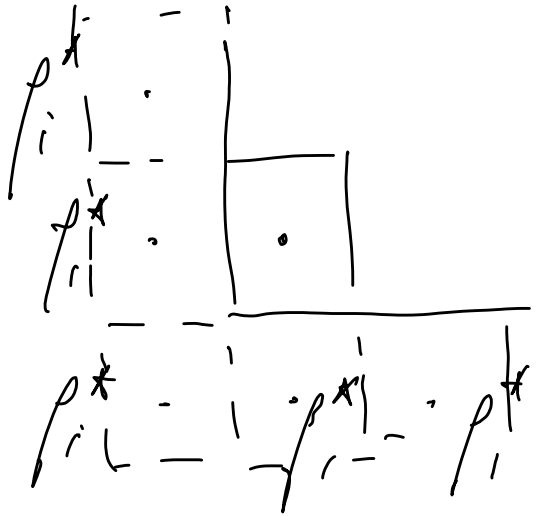
$\frac{D^3 g}{\nu^2}$

$\frac{m^3 \; m s^{-2}}{(m^2 s^{-1})^2} = -$

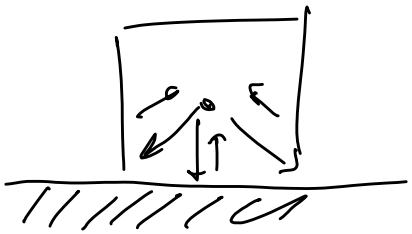
Boundary conditions $f_i^*(\vec{x}, t) = f_i(\vec{x}, t) + \Omega_i(\vec{x}, t)$

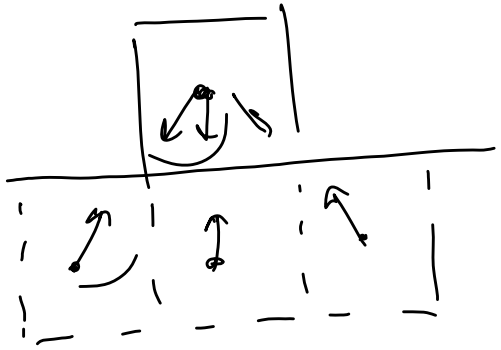
streaming $f_i(\vec{x} + \vec{c}_i, t+1) = f_i^*(\vec{x}, t)$

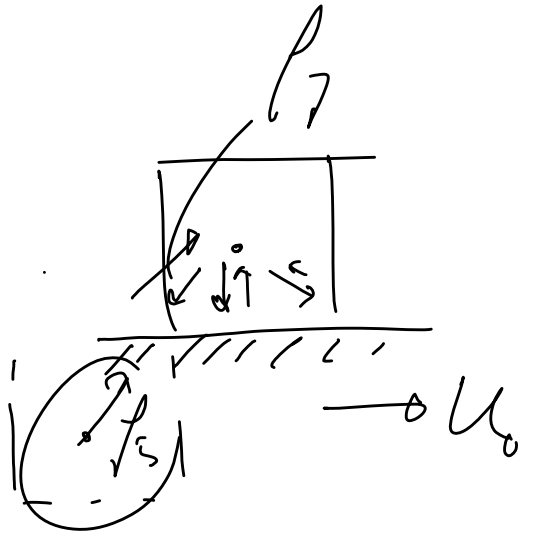




no-slip → bounce back rule



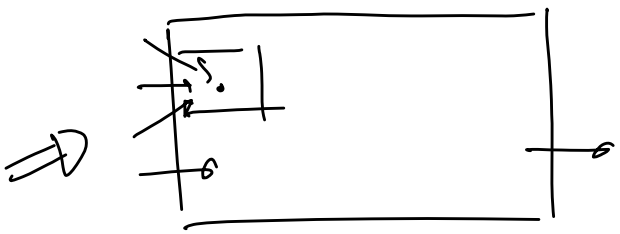


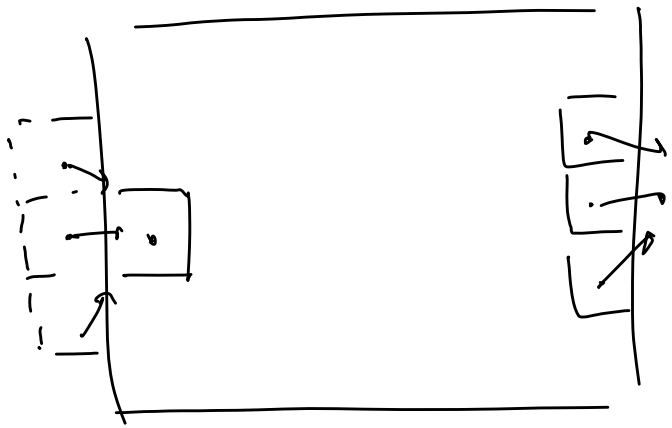


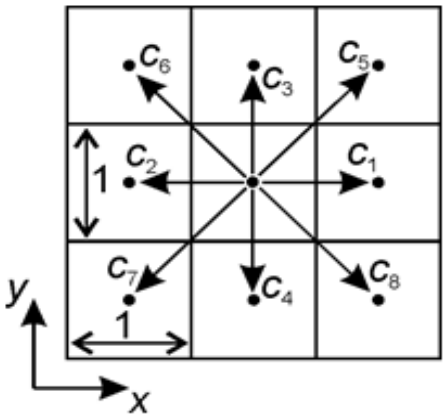
$$f_5(\vec{x}, t+1) = f_7^*(\vec{x}, t) + 2\rho u_0 w_7 / c_s^2$$

$$f_6(\vec{x}, t+1) = f_8^*(\vec{x}, t) - 2\rho u_0 w_8 / c_s^2$$

periodic boundary conditions



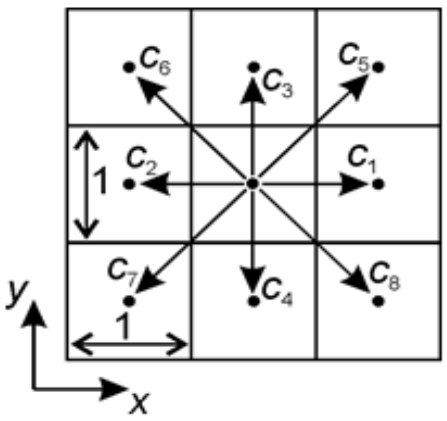


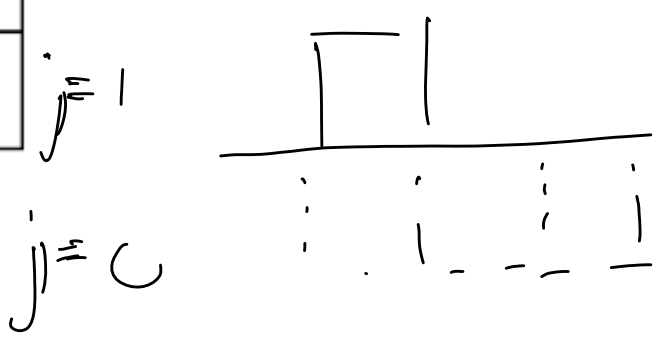



```
for j=1:ny
  for i=1:nx
    f(0,i,j)=fstar(0,i,j)
    f(1,i,j)=fstar(1,i-1,j)
    f(2,i,j)=fstar(2,i+1,j)
    f(3,i,j)=fstar(3,i,j-1)
    f(4,i,j)=fstar(4,i,j+1)
    f(5,i,j)=fstar(5,i-1,j-1)
    f(6,i,j)=fstar(6,i+1,j-1)
    f(7,i,j)=fstar(7,i+1,j+1)
    f(8,i,j)=fstar(8,i-1,j+1)
  end
end
```

```
for j=1:ny
  for i=1:nx
    f(2,i,j)=f(2,i+1,j)
    f(4,i,j)=f(4,i,j+1)
    f(7,i,j)=f(7,i+1,j+1)
    f(8,i,j)=f(8,i-1,j+1)
  end
end
for j=ny:-1:1
  for i=nx:-1:1
    f(1,i,j)=f(1,i-1,j)
    f(3,i,j)=f(3,i,j-1)
    f(5,i,j)=f(5,i-1,j-1)
    f(6,i,j)=f(6,i+1,j-1)
  end
end
```

```
% bounce back at bottom
j=0;
for i=1:nx
  x(3,i,j)=x(4,i,j+1);
  x(5,i,j)=x(7,i+1,j+1);
  x(6,i,j)=x(8,i-1,j+1);
end
```





```
for j=1:ny
  for i=1:nx
    rho=x(0,i,j)+x(1,i,j)+x(2,i,j)+x(3,i,j)+x(4,i,j)+x(5,i,j)+x(6,i,j)+
        x(7,i,j)+x(8,i,j);
    rrho=1.0/rho;
    ux=x(1,i,j)-x(3,i,j)+x(5,i,j)-x(6,i,j)-x(7,i,j)+x(8,i,j);
    ux=ux*rrho;
    uy=x(2,i,j)-x(4,i,j)+x(5,i,j)+x(6,i,j)-x(7,i,j)-x(8,i,j);
    uy=uy*rrho;
    usq=ux*ux+uy*uy;
    xeq(0)=m0*rho*(1.0-1.5*usq);
    cdotu=ux;
    xeq(1)=m1*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=uy;
    xeq(2)=m1*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=-ux;
    xeq(3)=m1*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=-uy;
    xeq(4)=m1*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=ux+uy;
    xeq(5)=m2*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=-ux+uy;
    xeq(6)=m2*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=-ux-uy;
    xeq(7)=m2*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    cdotu=ux-uy;
    xeq(8)=m2*rho*(1.0+3.0*cdotu+4.5*cdotu*cdotu-1.5*usq);
    for l=0:8
      x(l,i,j)=(1.0-rtau)*x(l,i,j)+rtau*xeq(l);
    end
  end
end
```