Poisson.for を利用して、mac.for を作成する。
ソースファイル名：mac.for，実行ファイル名：mac.out

```
$ cp   poisson.for     mac.for
$ vi    mac.for
$ gfortran   -o   mac.out     mac.for
$ ./ mac.out
```

```
      program mac

      parameter(imax = 30, jmax = 30)
      real*8   p(imax,jmax), pn(imax,jmax), g(imax,jmax)
      real*8   dx, dy, pmax, pmin, norm
      integer i, j, nx, ny
      character a(imax,jmax)

      [     ]   u(imax,jmax), v(imax,jmax), un(imax,jmax), vn(imax,jmax)
      [     ]   d(imax,jmax)
      [     ]   dt, re, tmp1, tmp2, tmp3, error
      integer nb
      character b(imax,jmax), c(imax,jmax)

      dt = 0.2; re = 1.;
      dx = 1.; dy = 1.; nx = 20; ny = 20

c..   initial condition
      do i = 1, nx; do j = 1, ny
        u(i,j) = 0.
        v(i,j) = 0.
        p(i,j) = 0.
        pn(i,j) = 0.
      enddo; enddo

      do m = 1, 3000

c..   boundary condition
        do i = 1,nx
          u(i,1 ) = 0.
          u(i,ny) = 0.
          v(i,1 ) = 0.
          v(i,ny) = 0.
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          pn(i,1 ) = pn(i,2)
          pn(i,ny) = pn(i,ny-1)
        end do

        do j = 1,ny
          u(1 ,j) = u(2 ,j)
          u(nx,j) = u(nx-1,j)
          v(1 ,j) = 0.
          v(nx,j) = 0.
          pn(1 ,j) = 1.0
          pn(nx,j) = 0.9
        end do

c..     pressure
        do n = 1, 1000

          do i = 1, nx; do j = 1, ny
            p(i,j) = pn(i,j)
          end do; end do

          do i = 2, nx-1
            do j = 2, ny-1
              d(i,j) = [          ]
     1                 [          ]

              g(i,j) = [          ]
     1                 [          ]
     2                 [          ]
     3                 [          ]
     4                 [          ]
            end do
          end do

          do i = 2,nx-1; do j = 2,ny-1
            pn(i,j) = [          ]
     1                [          ]
     2                [          ]
          end do; end do

          pmax = 0.; pmin = 100.; norm = 0.
```

$$\frac{\partial}{\partial t}\left(\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial x}\left(u\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial x}\left(v\frac{\partial u}{\partial y}\right)=-\frac{\partial^2 p}{\partial x^2}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2}{\partial x^2}\left(\frac{\partial u}{\partial x}\right)+\frac{\partial^2}{\partial y^2}\left(\frac{\partial u}{\partial x}\right)\right)$$

$$\frac{\partial}{\partial t}\left(\frac{\partial v}{\partial y}\right)+\frac{\partial}{\partial y}\left(u\frac{\partial v}{\partial x}\right)+\frac{\partial}{\partial y}\left(v\frac{\partial v}{\partial y}\right)=-\frac{\partial^2 p}{\partial y^2}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2}{\partial x^2}\left(\frac{\partial v}{\partial y}\right)+\frac{\partial^2}{\partial y^2}\left(\frac{\partial v}{\partial y}\right)\right)$$

$$\frac{\partial D}{\partial t}+\frac{\partial u}{\partial x}\frac{\partial u}{\partial x}+u\frac{\partial^2 u}{\partial x^2}+\frac{\partial v}{\partial x}\frac{\partial u}{\partial y}+v\frac{\partial^2 u}{\partial x\partial y}+\frac{\partial u}{\partial y}\frac{\partial v}{\partial x}+u\frac{\partial^2 v}{\partial x\partial y}+\frac{\partial v}{\partial y}\frac{\partial v}{\partial y}+v\frac{\partial^2 v}{\partial y^2}$$
$$=-\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 D}{\partial x^2}+\frac{\partial^2 D}{\partial y^2}\right)$$

$$D=\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}$$

$$\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}=-\left(\frac{\partial u}{\partial x}\frac{\partial u}{\partial x}+2\frac{\partial v}{\partial x}\frac{\partial u}{\partial y}+\frac{\partial v}{\partial y}\frac{\partial v}{\partial y}+u\frac{\partial D}{\partial x}+v\frac{\partial D}{\partial y}\right)-\frac{\partial D}{\partial t}$$

$$\frac{\partial D}{\partial t}=\frac{D^{n+1}-D^n}{\Delta t}\;\rightarrow\; D^{n+1}=0\;\rightarrow\;\frac{\partial D}{\partial t}=-\frac{D^n}{\Delta t}$$

$$\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}=-\left(\left(\frac{\partial u}{\partial x}\right)^2+2\frac{\partial u}{\partial y}\cdot\frac{\partial v}{\partial x}+\left(\frac{\partial v}{\partial y}\right)^2\right)+\frac{D^n}{\Delta t}$$

$$D=\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\;\rightarrow\; D_{i,j}=\frac{u_{i+1,j}-u_{i-1,j}}{2\Delta x}+\frac{v_{i,j+1}-v_{i,j-1}}{2\Delta y}$$

$$g=-\left(\left(\frac{\partial u}{\partial x}\right)^2+2\frac{\partial u}{\partial y}\cdot\frac{\partial v}{\partial x}+\left(\frac{\partial v}{\partial y}\right)^2\right)+\frac{D^n}{\Delta t}$$

$$\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}=g$$
$$\rightarrow\;\frac{p_{i+1,j}-2p_{i,j}+p_{i-1,j}}{\Delta x^2}+\frac{p_{i,j+1}-2p_{i,j}+p_{i,j-1}}{\Delta y^2}=g_{i,j}$$
$$\rightarrow\; p_{i,j}=\frac{p_{i+1,j}\Delta y^2+p_{i-1,j}\Delta y^2+p_{i,j+1}\Delta x^2+p_{i,j-1}\Delta x^2-g_{i,j}\Delta x^2\Delta y^2}{2\left(\Delta x^2+\Delta y^2\right)}$$

```
          do i = 1, nx; do j = 1, ny
            if(abs(p(i,j)-pn(i,j)) .gt. norm) norm = abs(p(i,j)-pn(i,j))
            if(pn(i,j) .gt. pmax) pmax = pn(i,j)
            if(pn(i,j) .lt. pmin) pmin = pn(i,j)
          end do; end do

          if(norm   .le. 0.01) go to 100

        enddo

100     do i = 1, nx; do j = 1, ny
          p(i,j) = pn(i,j)
        end do; end do

c..     velocity
        do i = 1, nx; do j = 1, ny
          un(i,j) = u(i,j)
          vn(i,j) = v(i,j)
        end do; end do

        do i = 2, nx-1
          do j = 2, ny-1
            tmp1 = [                              ]
            tmp2 = vn(i,j)*(un(i,j+1) - un(i,j-1))/dy*0.5
            tmp3 = (un(i+1,j   ) - 2.*un(i,j) + un(i-1,j   ))/dx**2
     1             + (un(i   ,j+1) - 2.*un(i,j) + un(i   ,j-1))/dy**2
            u(i,j) = un(i,j)
     1        - dt*(tmp1 + tmp2 + 0.5*(p(i+1,j)-p(i-1,j))/dx - tmp3/re)

            tmp1 = un(i,j)*(vn(i+1,j) - vn(i-1,j))/dx*0.5
            tmp2 = vn(i,j)*(vn(i,j+1) - vn(i,j-1))/dy*0.5
            tmp3 = [                                    ]
     1             +[                                    ]
            v(i,j) = vn(i,j)
     1        - dt*(tmp1 + tmp2 + 0.5*(p(i,j+1)-p(i,j-1))/dy - tmp3/re)
          end do
        end do

        error = 0.
        do j = 1, ny
```

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{\partial p}{\partial x}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

$\rightarrow$

$$\frac{u_{i,j}^{n+1}-u_{i,j}^{n}}{\Delta t}+u_{i,j}^{n}\frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}+v_{i,j}^{n}\frac{u_{i,j+1}^{n}-u_{i,j-1}^{n}}{2\Delta y}$$
$$=-\frac{p_{i+1,j}^{n}-p_{i-1,j}^{n}}{2\Delta x}+\frac{1}{\mathrm{Re}}\left(\frac{u_{i+1,j}^{n}-2u_{i,j}^{n}+u_{i-1,j}^{n}}{\Delta x^2}+\frac{u_{i,j+1}^{n}-2u_{i,j}^{n}+u_{i,j-1}^{n}}{\Delta y^2}\right)$$

$\rightarrow u(i,j)=u_{i,j}^{n+1},\ \ un(i,j)=u_{i,j}^{n},\ v(i,j)=v_{i,j}^{n+1},\ \ vn(i,j)=v_{i,j}^{n}$

$$tmp1=u_{i,j}^{n}\frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}\quad tmp2=v_{i,j}^{n}\frac{u_{i,j+1}^{n}-u_{i,j-1}^{n}}{2\Delta y}$$

$$tmp3=\frac{u_{i+1,j}^{n}-2u_{i,j}^{n}+u_{i-1,j}^{n}}{\Delta x^2}+\frac{u_{i,j+1}^{n}-2u_{i,j}^{n}+u_{i,j-1}^{n}}{\Delta y^2}$$

$$u_{i,j}^{n+1}=u_{i,j}^{n}-\Delta t\left(tmp1+tmp2+\frac{p_{i+1,j}^{n}-p_{i-1,j}^{n}}{2\Delta x}-\frac{tmp3}{\mathrm{Re}}\right)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{\partial p}{\partial y}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$

$$\rightarrow\ tmp1=u\frac{\partial v}{\partial x},\ tmp2=v\frac{\partial v}{\partial y},\ tmp3=\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}$$

$$\rightarrow\ v_{i,j}^{n+1}=v_{i,j}^{n}-\Delta t\left(tmp1+tmp2+\frac{p_{i,j+1}^{n}-p_{i,j-1}^{n}}{2\Delta y}-\frac{tmp3}{\mathrm{Re}}\right)$$

```
          tmp1 = abs(u(nx/2, j) + re*0.05/(nx-1)*(j**2 - (ny+1)*j + ny))
          if(tmp1 .gt. error) error = tmp1
        enddo

c.. graphics
        if(mod(m,100) .eq. 0) then
         write(*,*) m, error, u(nx/2,ny/2)
         do i = 1, nx; do j = 1, ny
          if(p(i,j) .le. pmax*1.0              ) a(i,j)= '9'
          if(p(i,j) .le. pmax*0.9 + pmin*0.1) a(i,j)= '8'
          if(p(i,j) .le. pmax*0.8 + pmin*0.2) a(i,j)= '7'
          if(p(i,j) .le. pmax*0.7 + pmin*0.3) a(i,j)= '6'
          if(p(i,j) .le. pmax*0.6 + pmin*0.4) a(i,j)= '5'
          if(p(i,j) .le. pmax*0.5 + pmin*0.5) a(i,j)= '4'
          if(p(i,j) .le. pmax*0.4 + pmin*0.6) a(i,j)= '3'
          if(p(i,j) .le. pmax*0.3 + pmin*0.7) a(i,j)= '2'
          if(p(i,j) .le. pmax*0.2 + pmin*0.8) a(i,j)= '1'
          if(p(i,j) .le. pmax*0.1 + pmin*0.9) a(i,j)= '0'
         end do; end do

         do i = 1, nx; do j = 1, ny
          b(i,j)= '0'
         end do; end do
         do j = 1, ny
          nb = int(u(nx/2,j)*75)
          do i = 1, nb
           b(i,j)= '-'
          end do
         end do

         do i = 1, nx; do j = 1, ny
          c(i,j)= '0'
         end do; end do
         do j = 1, ny
          nb = int((-re*0.05/(nx-1)*(j**2 - (ny+1)*j + ny))*75)
          do i = 1, nb
           c(i,j)= '-'
          end do
         end do
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```
          do j = ny,1,-1
            write(*,*) (a(i,j),i = 1,nx),'   '
     &                      ,(b(i,j),i = 1,nx),'    ',(c(i,j),i = 1,nx)
          end do
          write(*,*) '*----------------------------*'
        endif

      end do

      call exceldata(                    )

      stop
      end

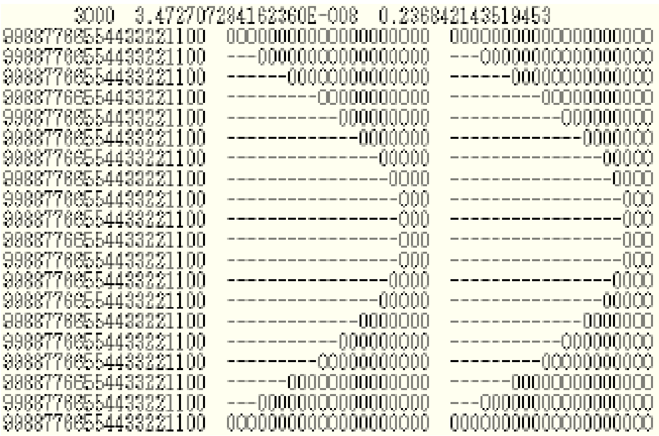
      subroutine exceldata(                    )
      real*8
      integer

      open(unit = 10, file = 'pressure', status= 'unknown')
        do j = 1, ny
          write(10,200)(p(i, j), i = 1, nx)
        end do
      close(10)

200   format(1x, 20e15.6)
      return
      end
```

《結果》

3000　　3.472707284162360E-008　　0.236842143519453



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