1) Material derivative is the rate of change with respect to a moving fluid particle.

2) Peclet $= \frac{UL}{\mathcal{D}}$ ratio of time for convection to time for diffusion.

3) $$\frac{Dc}{Dt} = \frac{\partial c}{\partial t} + \vec{v} \cdot \nabla c = \mathcal{D} \nabla^2 c$$

when $\vec{v} \cdot \nabla c = 0$ then we have the regular diffusion equation.

true when $\underline{\vec{v} = 0}$ - or -

$$u \frac{\partial c}{\partial x} + v \frac{\partial c}{\partial y} = 0$$

the later can occur when $u \neq 0$ $v = 0$

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

Most common when there is no flow.

4) $\nabla \cdot \vec{V} = 0$

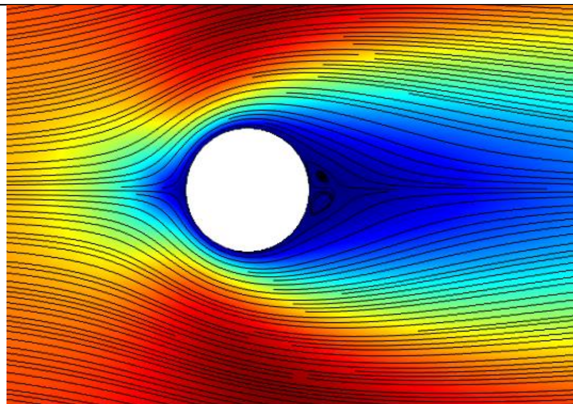
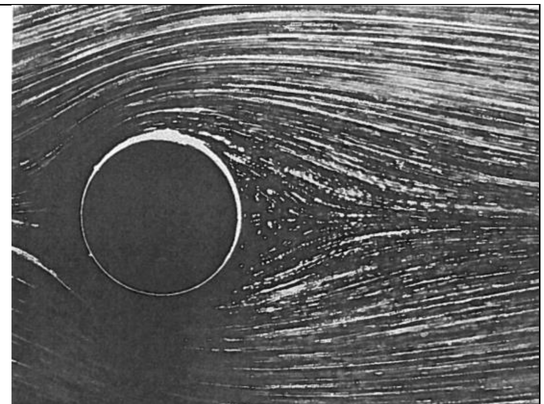
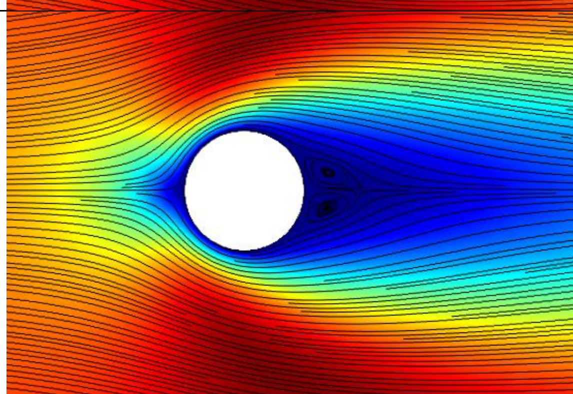
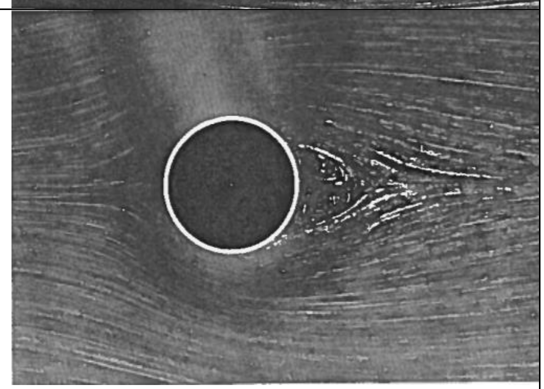
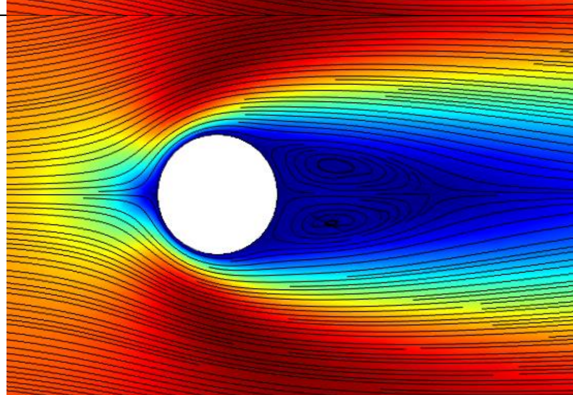
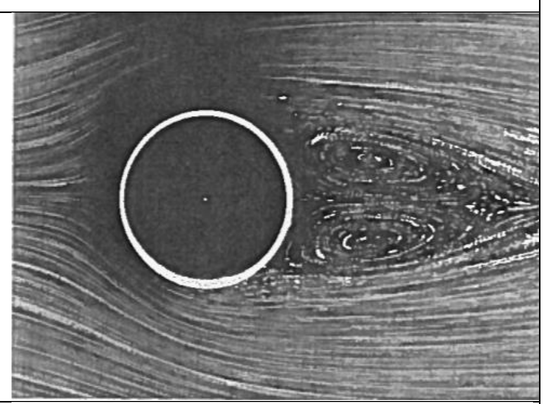
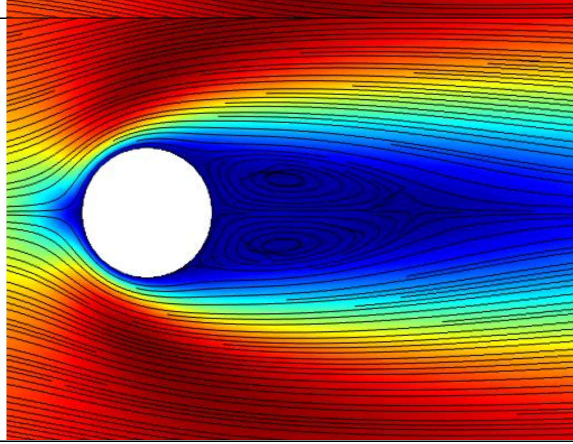
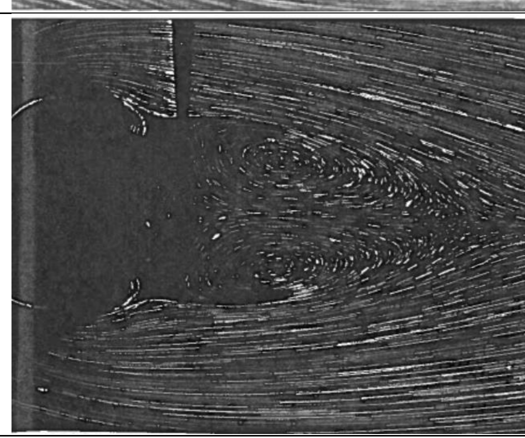
Conservation of mass for incompressible flow. Not valid when density is not a Constant.

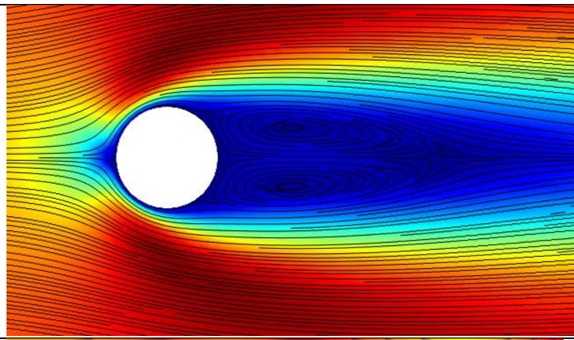
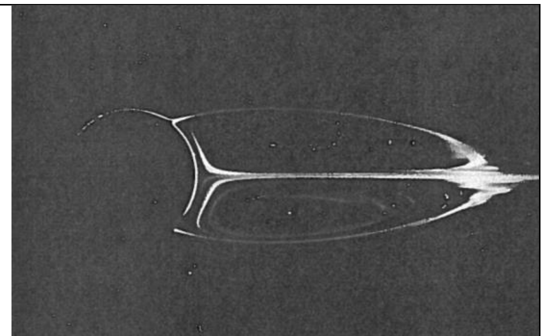
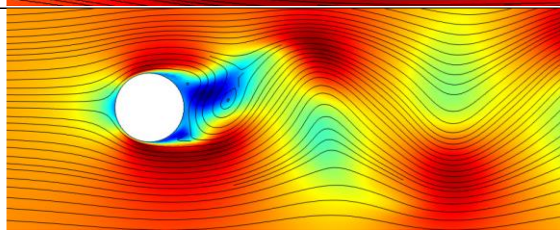
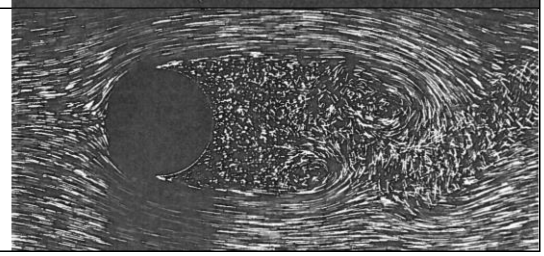
5) $$\frac{\partial c}{\partial t} + \nabla \cdot (c\vec{v}) = \frac{\partial c}{\partial t} + \vec{V} \cdot \nabla c + c \nabla \cdot \vec{v}$$

$$= \frac{Dc}{Dt} + c \nabla \cdot \vec{v}$$

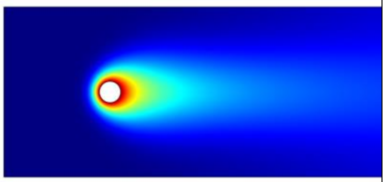
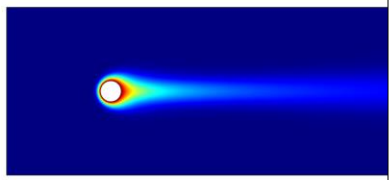
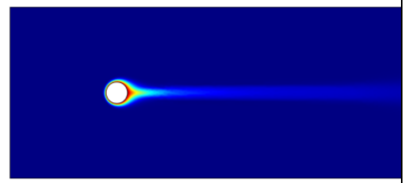
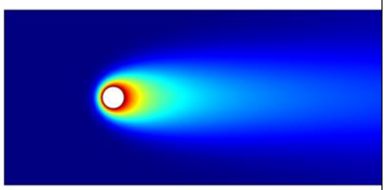
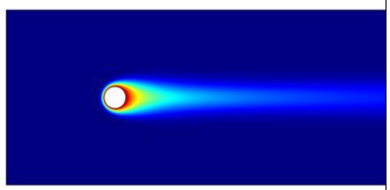
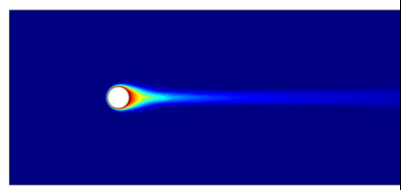
So when flow is incompressible

$$\frac{\partial c}{\partial t} + \nabla \cdot (c\vec{v}) = \frac{Dc}{Dt}$$

R=9.6		
R=13.1		
R=26		
R=30.2		

R=41		
R=2000		

The agreement above looks pretty good except at Re=2000. At lower Re, if you measure the size of the wake where the streamlines re-connect in terms of cylinder diameters, the match is really good. At Re=2000, the experiment shows a lot of turbulence and structure in the wake, so it is expected (at least to me!) that the simulation cannot resolve all this detail. The point where I could clearly see unsteady flow gas around Re=90. This is higher than the experimentally reported value of a little over 40. However, when thinking logarithmically, this isn't bad agreement. Also, capturing these instabilities is a challenge and it is actually pretty good that we can get this close without much effort.

	Pe=10	Pe=100	Pe=1000
Re 1			
Re 10			
Re 100