

Potential Flow

Lecture 5



ME EN 412
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Outline

Equation Hierarchy

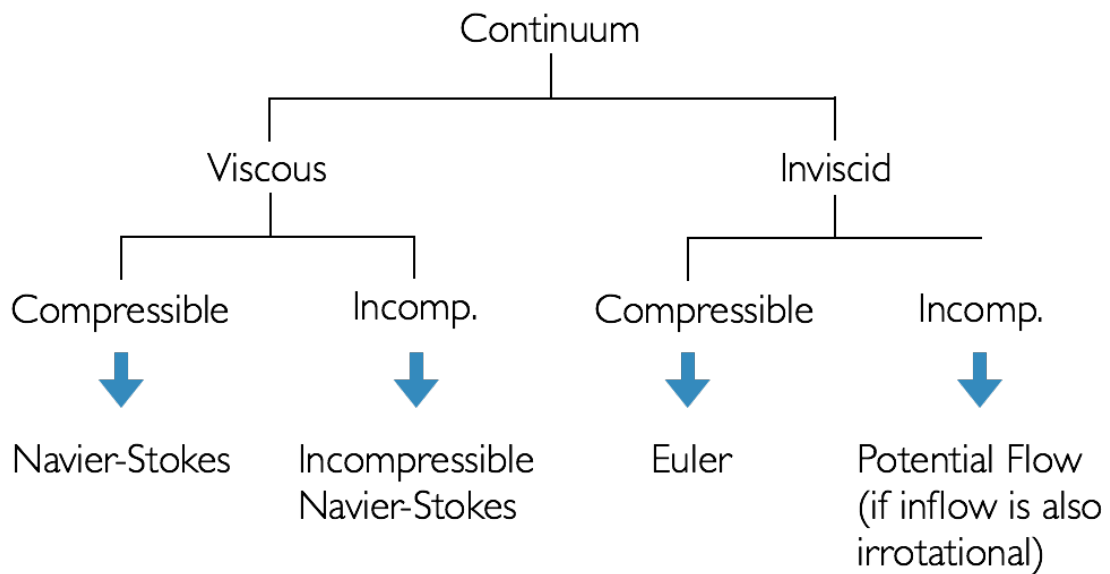
Potential Flow

Panel Methods

Other Considerations

Equation Hierarchy

Equation Hierarchy



When is an inviscid flow assumption valid?

Video: flow over a car

Potential Flow

Incompressible:

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

Irrotational:

$$\nabla \times \vec{V} = 0$$

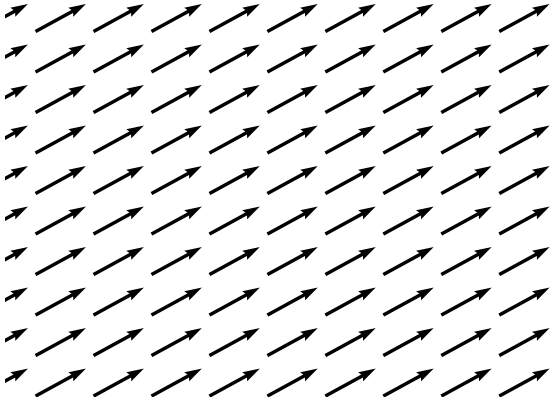
$$\nabla^2 \phi = 0$$

Velocity Field

$$\vec{V} = \nabla \phi \quad \Rightarrow$$

$$V_x = \frac{\partial \phi}{\partial x}, \quad V_y = \frac{\partial \phi}{\partial y}, \quad V_z = \frac{\partial \phi}{\partial z}$$

Uniform Flow



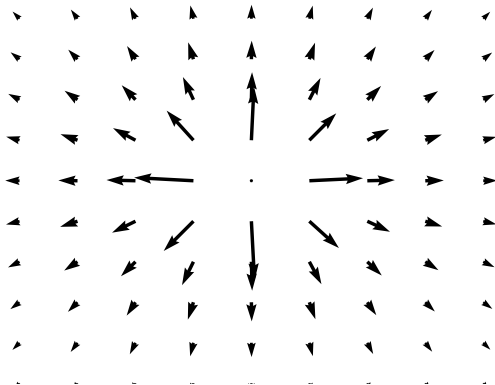
$$\phi = U \cos \alpha x + U \sin \alpha y$$

$$\psi = -U \sin \alpha x + U \cos \alpha y$$

$$V_x = U \cos \alpha$$

$$V_y = U \sin \alpha$$

Source/Sink



$$\phi = \frac{\Lambda}{2\pi} \ln r$$

$$\psi = \frac{\Lambda}{2\pi} \theta$$

$$V_r = \frac{\Lambda}{2\pi r}$$

$$V_\theta = 0$$

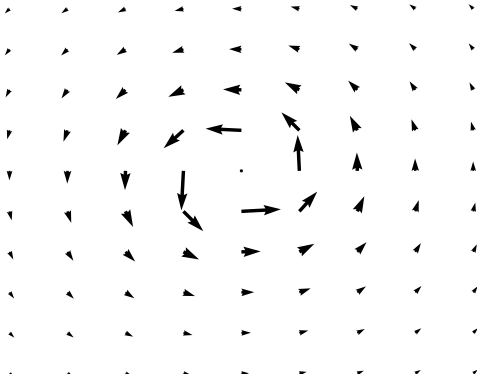
1. Is my use of social media impeding or inviting the constant companionship of the Holy Ghost in my life?

2. Does the time I spend on social media restrict or enlarge my capacity to live, love, and serve in meaningful ways?

- Elder Bednar

With that understanding, I no longer needed lists of dos and don'ts. When I had to make a decision whether or not an activity was appropriate for the Sabbath, I simply asked myself, What sign do I want to give to God? That question made my choices about the Sabbath day crystal clear.

- Elder Nelson



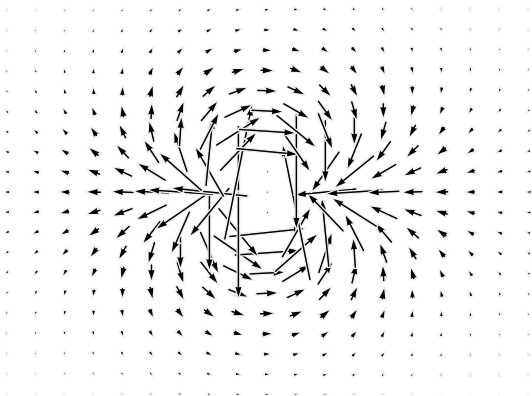
$$\phi = \frac{\Gamma}{2\pi}\theta$$

$$\psi = -\frac{\Gamma}{2\pi}\ln r$$

$$V_r = 0$$

$$V_\theta = \frac{\Gamma}{2\pi r}$$

Doublet



$$\phi = \frac{\kappa \cos \theta}{2\pi r}$$

$$\psi = -\frac{\kappa \sin \theta}{2\pi r}$$

$$V_r = -\frac{\kappa \cos \theta}{2\pi r^2}$$

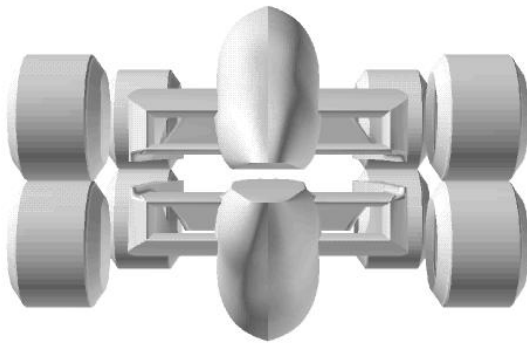
$$V_\theta = -\frac{\kappa \sin \theta}{2\pi r^2}$$

Combine uniform flow and a source.

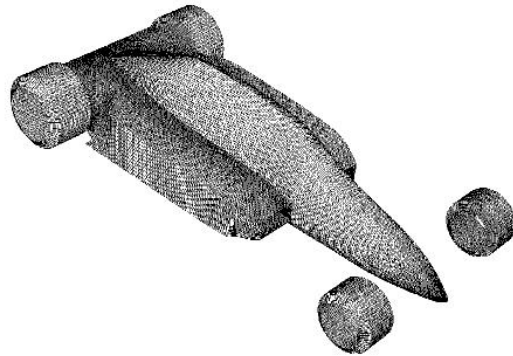
Combine uniform flow and a doublet.

Panel Methods

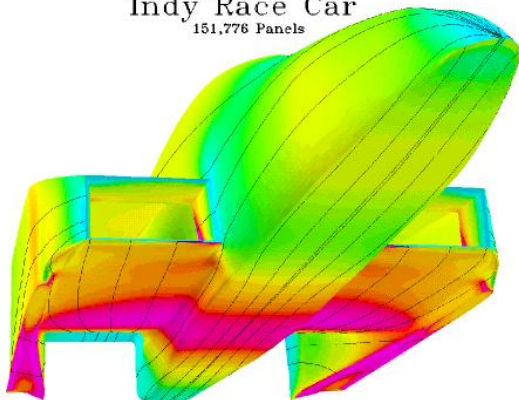
Indy Race Car
151,776 Panels



Indy Race Car
151,776 Panels



Indy Race Car
151,776 Panels



Other Considerations

Vortex Motion

<https://youtu.be/dfY5ZQDzC5s>

Ground Effect



Boeing Phantom Works

Streamlines

$$\nabla^2 \Psi(x, y) = 0$$

(only in 2D)