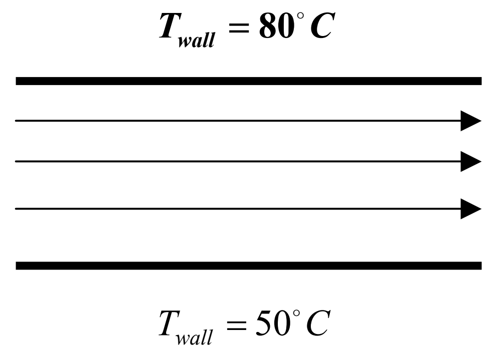
Given the following flow paths and temperatures:



Which of these is most likely true:

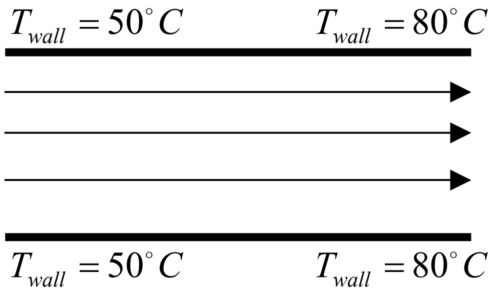
$$(1) \quad \frac{DT}{Dt} = 0$$

$$(2) \quad \frac{DT}{Dt} \neq 0$$

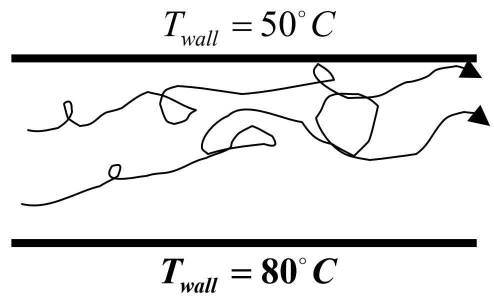
darmofal:

1

Given the following flow paths and temperatures:



(A)



(B)

Which of these is most likely true:

(1) $\left.\dfrac{DT}{Dt}\right|_A = 0$ **and** $\left.\dfrac{DT}{Dt}\right|_B \neq 0$

(2) $\left.\dfrac{DT}{Dt}\right|_A \neq 0$ **and** $\left.\dfrac{DT}{Dt}\right|_B = 0$

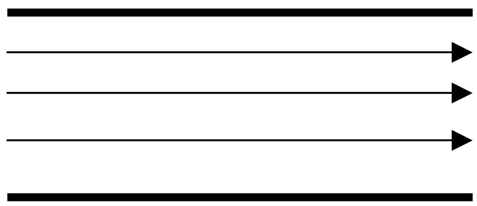
(3) $\left.\dfrac{DT}{Dt}\right|_A = 0$ **and** $\left.\dfrac{DT}{Dt}\right|_B = 0$

(4) $\left.\dfrac{DT}{Dt}\right|_A \neq 0$ **and** $\left.\dfrac{DT}{Dt}\right|_B \neq 0$

darmofal:

4

Given the following two-dimensional flow paths



Arrows do not indicate velocity magnitude, only direction

Which of these is most likely true:

$$(1) \quad \frac{D\vec{V}}{Dt} = 0$$

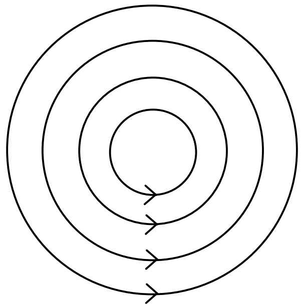
$$(2) \quad \frac{D\vec{V}}{Dt} \neq 0$$

(3) Not enough information

darmofal:

3

Given the following two-dimensional flow paths:



Arrows do not indicate velocity magnitude, only direction

Which of these is most likely true:

(1) $$\frac{D\vec{V}}{Dt} = 0$$

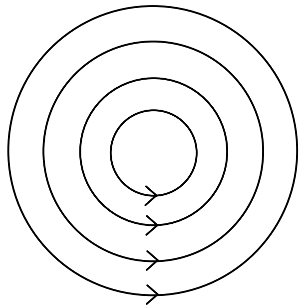
(2) $$\frac{D\vec{V}}{Dt} \neq 0$$

(3) Not enough information

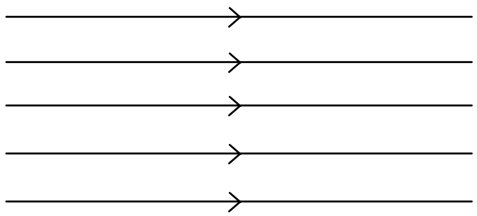
darmofal:

2

Given the following streamlines for a steady, two dimensional flow:



(a)



(b)

Which of these flows is irrotational:

(1) Only (a)

(2) Only (b)

(3) Both (a) & (b)

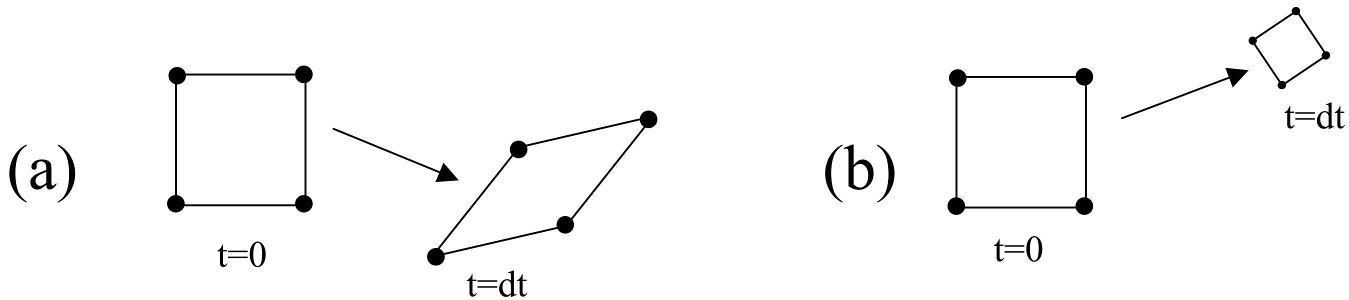
(4) Neither

(5) Not enough information

darmofal:

5

Consider the motion of two fluid elements:



Which of these fluid element motions could be from an incompressible flow:

(1) Only (a)

(2) Only (b)

(3) Both (a) & (b)

(4) Neither

(5) Not enough information

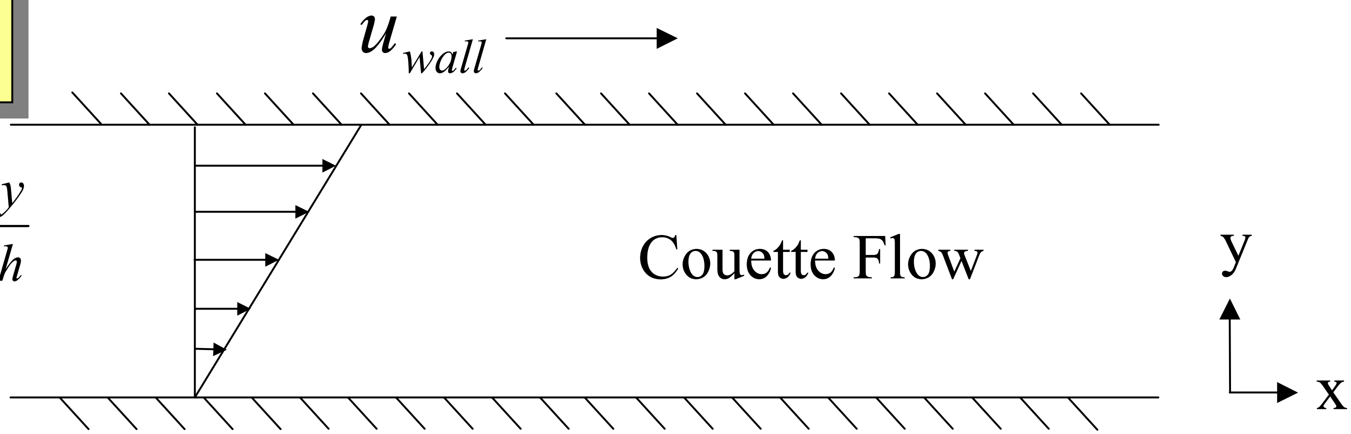
darmofal:

1

darmofal:
2

$$u = u_{wall}\,\frac{y}{h}$$

$$v = 0$$



Viscous force acting on the lower wall is:	Viscous force acting on the upper wall is:
(+0) = in +x direction	(+0) = in +x direction
(+1) = in -x direction	(+2) = in -x direction

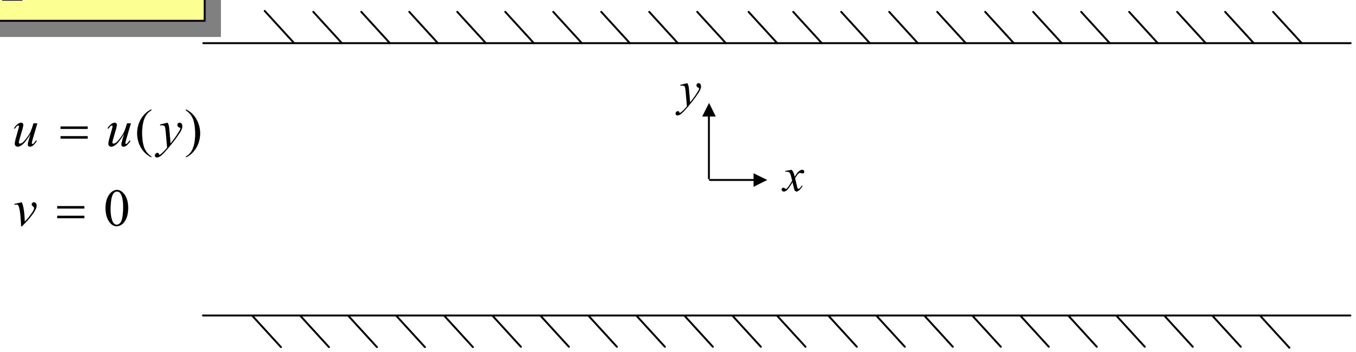
Choose one from each column and enter your total (0-3)

OR

Enter (4) for none of these combinations are correct

darmofal:

2



Consider channel flow as shown above. What is the net viscous force acting on the fluid in the x-direction (per unit depth)?

1) $\left[\tau_{yx}(h)+\tau_{yx}(-h)\right]\times L$

2) $\left[\tau_{yx}(h)-\tau_{yx}(-h)\right]\times L$

3) $\left[-\tau_{yx}(h)+\tau_{yx}(-h)\right]\times L$

4) $\left[-\tau_{yx}(h)-\tau_{yx}(-h)\right]\times L$

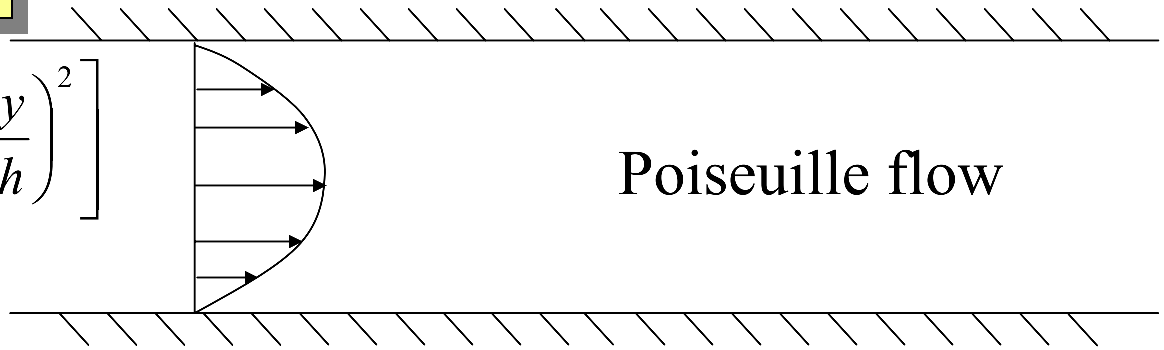
5) None of the above

darmofal:

6

$$u = u_0\left[1 - \left(\frac{y}{h}\right)^2\right]$$

$$v = 0$$



Acceleration of fluid element	**Net Pressure Force on a fluid element**	**Net Viscous Force on a fluid element**
(+0) = zero	(+0) = zero	(+0) = zero
(+1) = In $\pm x$ direction	(+2) = In $\pm x$ direction	(+4) = In $\pm x$ direction

Choose one from each column and enter your total (0-7)

OR

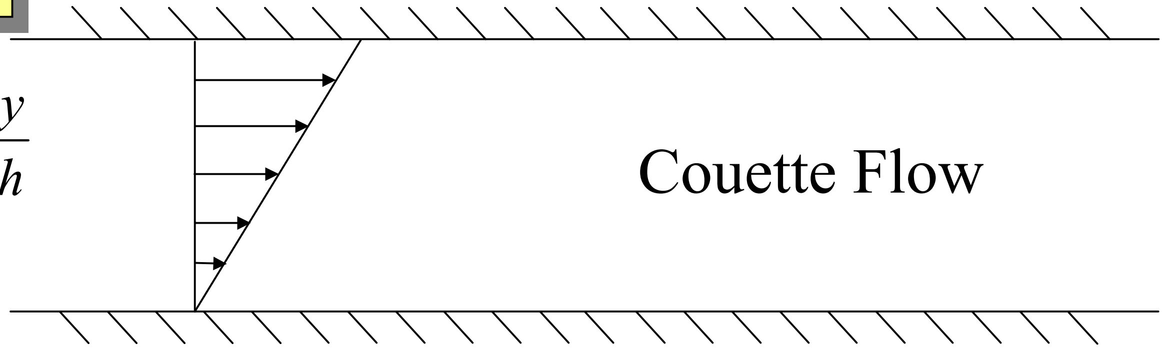
Enter (8) for none of these combinations are correct

darmofal:

0

$$u = u_{wall} \frac{y}{h}$$

$$v = 0$$



Acceleration of fluid element

(+0) = zero

(+1) = In $\pm x$ direction

Net Pressure Force on a fluid element

(+0) = zero

(+2) = In $\pm x$ direction

Net Viscous Force on a fluid element

(+0) = zero

(+4) = In $\pm x$ direction

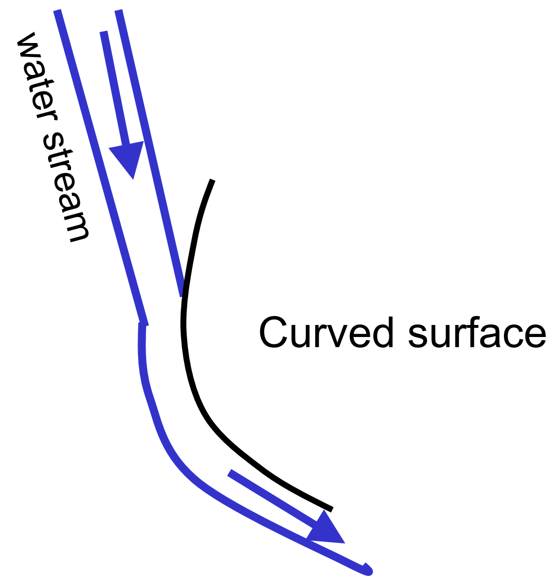
Choose one from each column and enter your total (0-7)

OR

Enter (8) for none of these combinations are correct

darmofal:

1



When the water stream contacts the curved surface, which way will the surface move:

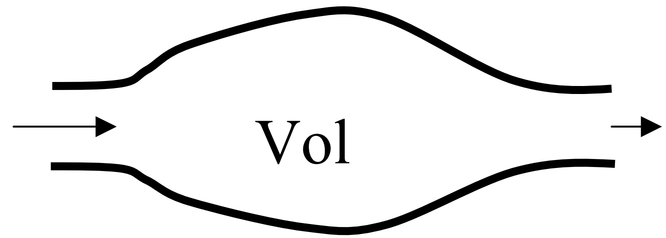
1. Pulled into the stream
2. Push away from the stream

Consider the following flow through a device:

$\rho_L = 1 \text{ kg/ft}^3$

$u_L = 1 \text{ ft/sec}$

$S_L = 1 \text{ ft}^2$



$\rho_R = 2 \text{ kg/ft}^3$

$u_R = \frac{1}{2} \text{ ft/sec}$

$S_R = 1 \text{ ft}^2$

Which of these true:

$$(1) \quad \frac{d}{dt}\int_{Vol} \rho \, dV = 0$$

$$(2) \quad \frac{d}{dt}\int_{Vol} \rho \, dV \neq 0$$

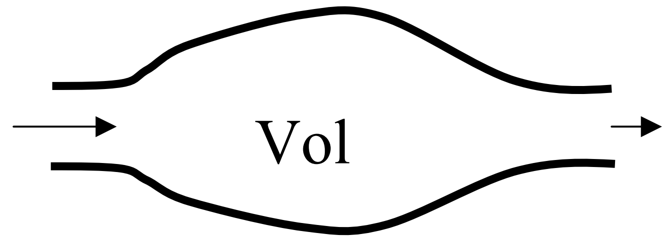
(3) Not enough information

darmofal:

1

Consider the following flow through a device:

$$\rho_L = 1 \ \text{kg/ft}^3 \qquad u_L = 1 \ \text{ft/sec} \qquad S_L = 1 \ \text{ft}^2$$



$$\rho_R = 2 \ \text{kg/ft}^3 \qquad u_R = \frac{1}{2} \ \text{ft/sec} \qquad S_R = 1 \ \text{ft}^2$$

Which of these true:

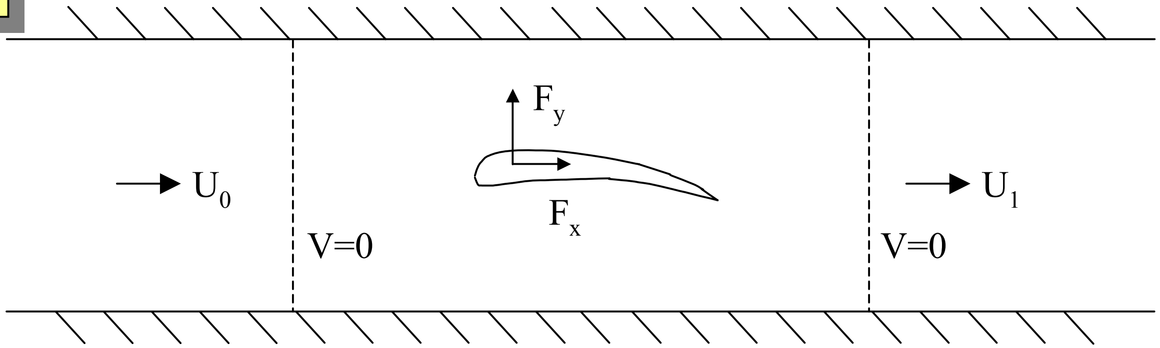
$$(1) \quad \frac{d}{dt}\int_{Vol} \rho u \, dV = 0$$

$$(2) \quad \frac{d}{dt}\int_{Vol} \rho u \, dV \neq 0$$

(3) Not enough information

darmofal:
3

darmofal:
1

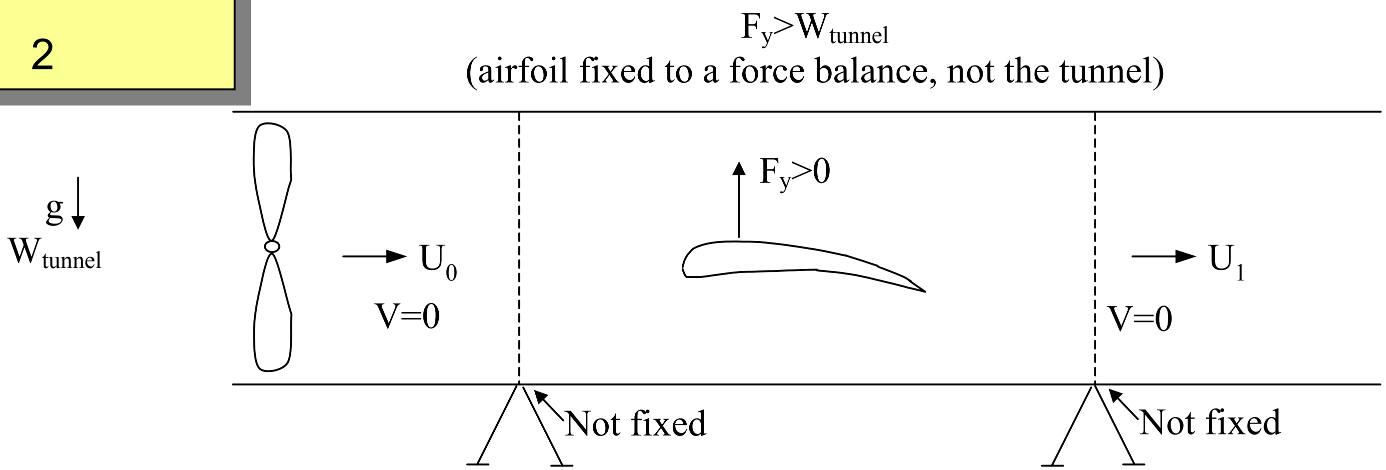


An airfoil which has $F_y>0$ when flying at speed U_0 in the atmosphere is placed in a wind tunnel with a straight wall test section. The velocity a few chords upstream & downstream have V=0. Which of the following is most likely true?

1) $F_y>0$
2) $F_y<0$
3) $F_y=0$

darmofal:

2



An airfoil is placed in a wind tunnel and experiences a lifting force $F_y > 0$. Given a very light tunnel such that $W_{tunnel} < F_y$: True or False: will the tunnel "lift off"

1) True

2) False

darmofal:

3

Assuming an incompressible, inviscid flow with a uniform freestream, which of the following is true?

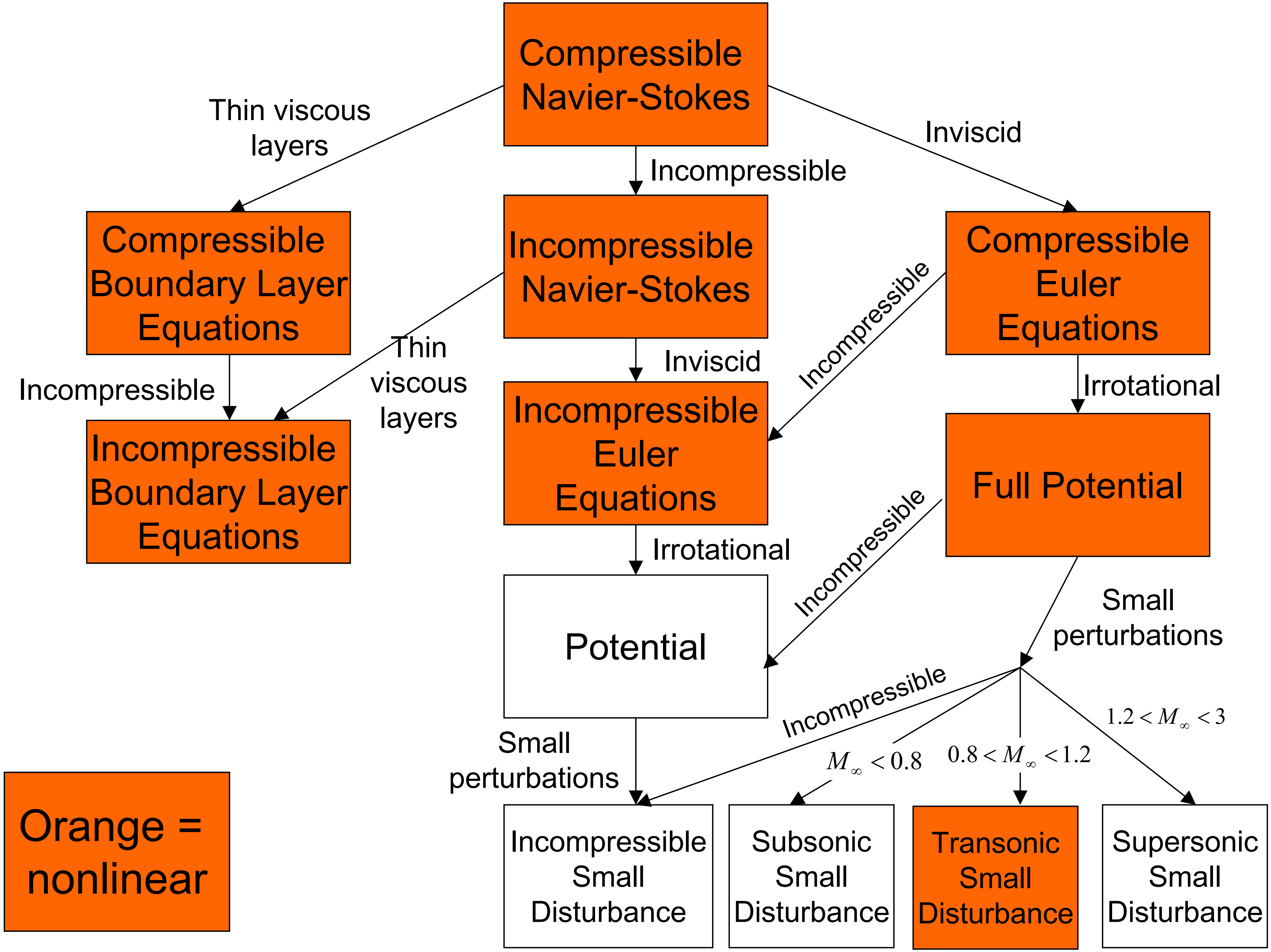
$$\boxed{\text{Note}: \vec{\omega} = \nabla \times \vec{V}}$$

(1) $\left|\vec{\omega}\right|_A > \left|\vec{\omega}\right|_B$

(2) $\left|\vec{\omega}\right|_A < \left|\vec{\omega}\right|_B$

(3) $\left|\vec{\omega}\right|_A = \left|\vec{\omega}\right|_B$

(4) Not enough info



Compressible Navier-Stokes
Thin viscous layers
Incompressible
Inviscid
Compressible Boundary Layer Equations
Incompressible Navier-Stokes
Compressible Euler Equations
Incompressible
Thin viscous layers
Inviscid
Incompressible
Irrotational
Incompressible Boundary Layer Equations
Incompressible Euler Equations
Full Potential
Irrotational
Incompressible
Potential
Small perturbations
Incompressible
$1.2 < M_\infty < 3$
Small perturbations
$M_\infty < 0.8$
$0.8 < M_\infty < 1.2$
Incompressible Small Disturbance
Subsonic Small Disturbance
Transonic Small Disturbance
Supersonic Small Disturbance
Orange = nonlinear

darmofal:

2

Given an arbitrary function $\phi(x, y, z)$ and the associated velocity field $\vec{v} = \nabla\phi$. The velocity field:

(1) Satisfies conservation of mass for an incompressible flow

(2) Is irrotational

(3) Both of the above

(4) None of the above

darmofal:

1

Given two potentials ϕ_1 & ϕ_2, and the associated velocity fields, $\vec{v}_1 = \nabla\phi_1$ and $\vec{v}_2 = \nabla\phi_2$, we add the potentials to find a new potential, $\phi_3 = \phi_1 + \phi_2$. Assuming an inviscid, incompressible flow:

(1) $\vec{v}_3 = \vec{v}_1 + \vec{v}_2$

(2) $p_3 = p_1 + p_2$

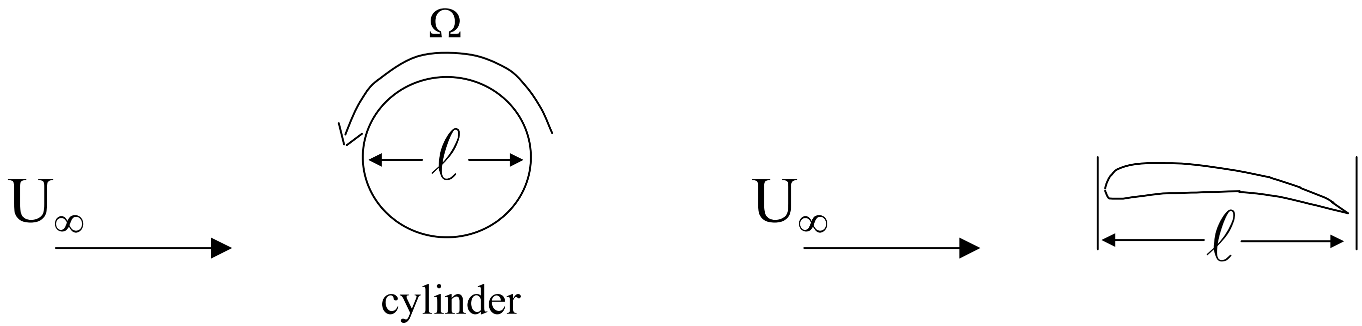
(3) Both of the above.

(4) None of the above.

darmofal:

3

In a 2-D incompressible, inviscid flow with a uniform freestream, which of the following is true?



(1) $\text{Drag}_{\text{cyl}} > \text{Drag}_{\text{airfoil}}$

(2) $\text{Drag}_{\text{cyl}} < \text{Drag}_{\text{airfoil}}$

(3) $\text{Drag}_{\text{cyl}} = \text{Drag}_{\text{airfoil}}$

(4) Not enough info

darmofal: 4

Assuming 2-D, incompressible, steady potential flow around an airfoil, which is true:

(1) If $L' = \rho V_\infty \Gamma$, then the Kutta condition must be satisfied.

(2) If the lift is non-zero, then the Kutta condition must be satisfied.

(3) Both of the above.

(4) None of the above.

For $c_l = 0.5$, which is true about the leading-edge stagnation points for the 4202 and 0002 airfoils:

(1) 4202 = lower surface, 0002 = lower surface

(2) 4202 = upper surface, 0002 = upper surface

(3) 4202 = lower surface, 0002 = upper surface

(4) 4202 = upper surface, 0002 = lower surface

darmofal:

1 (Note: there is a plot missing in this viewgraph that was shown in class).

darmofal:

1

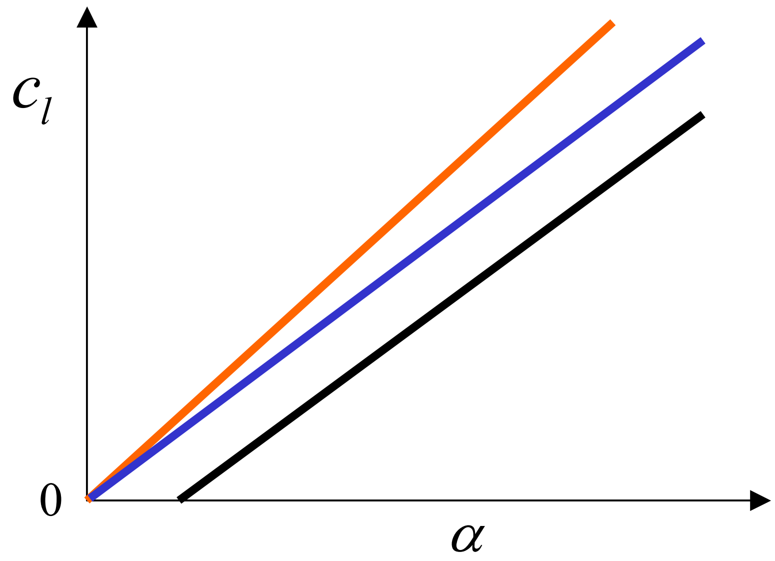
Consider two airfoils that have the same design lift coefficient: one a standard cambered airfoil, the other a reflexed airfoil. Which of the airfoils will generally have the lowest surface pressure (i.e. most negative Cp):

(1) Airfoil without reflex

(2) Airfoil with reflex

darmofal:

3



Two of the three lines **are** from thin airfoil theory, one line is not:

1) The **black** line is not thin airfoil theory

2) The **blue** line is not thin airfoil theory

3) The **red** line is not thin airfoil theory

4) Not enough information

darmofal:

1

According to thin airfoil theory, which is true:

(1) The moment at c/4 is constant with respect to angle of attack

(2) The moment at c/4 is zero when the lift is zero.

(3) Both of the above

(4) None of the above

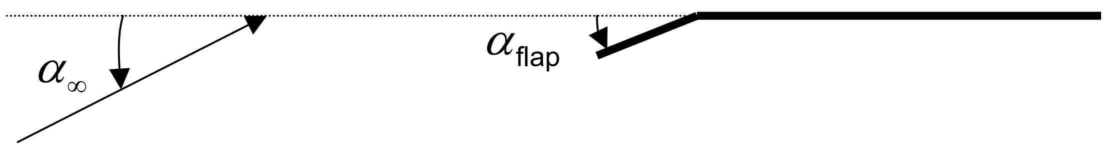
darmofal:

3

Consider a symmetric airfoil in a flow which is at an angle of attack. To eliminate the leading edge suction peak, the leading is deflected downwards using a flap. Which is true?

(1) $\alpha_{\text{flap}} < \alpha_\infty$

(2) $\alpha_{\text{flap}} \approx \alpha_\infty$



(3) $\alpha_{\text{flap}} > \alpha_\infty$

(4) Not enough information

darmofal:

2

For an airplane (or airfoil) which is statically stability, which of the following is true:

$(+0) : x_{cp} < x_{ac}$	$(+0) : M_{ac} < 0$
$(+1) : x_{cp} > x_{ac}$	$(+2) : M_{ac} > 0$

Choose one from each column and enter your total (0-3)

OR

Enter (4) if there is not enough information

darmofal:

6

For a 3-D incompressible potential flow, which is true:

(1) If L=0 then D=0

(2) If D=0 then L=0

(3) If $L \neq 0$ then $D \neq 0$

(4) 1+2

(5) 1+3

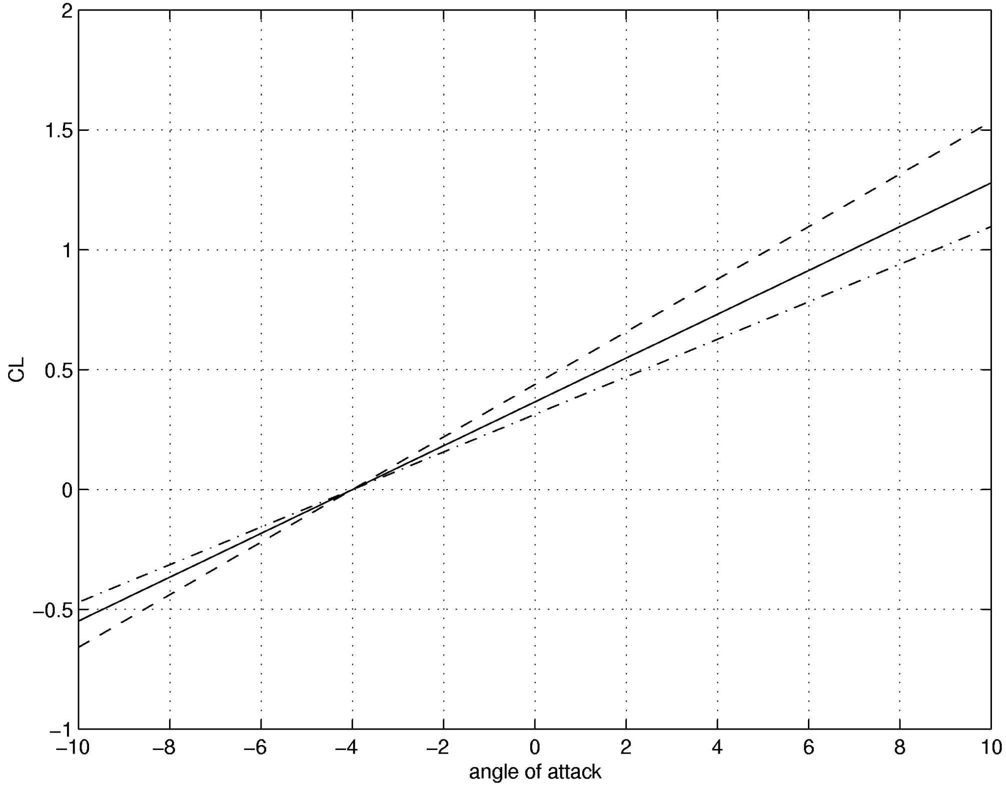
(6) 2+3

(7) All (1+2+3)

(8) None

darmofal:

3



The following results are from a lifting line analysis of three wings **all** with the same cambered airfoil. Which wing is the **solid line:**

1) 2-D airfoil

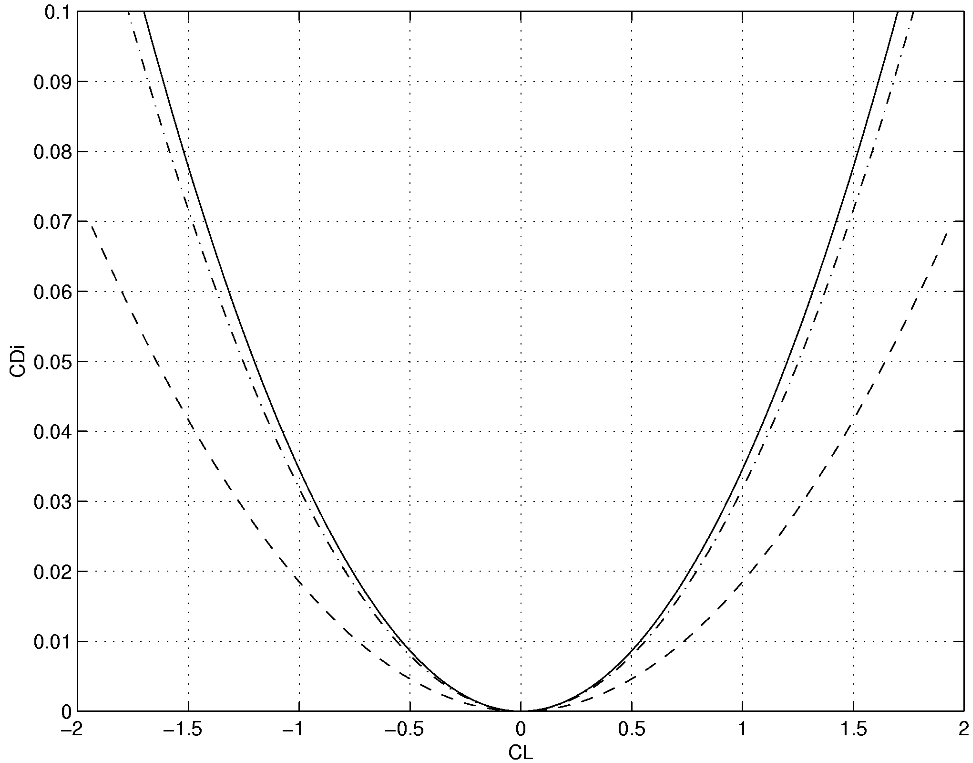
2) Elliptic planform, no geometric twist, AR=5

3) Elliptic planform, no geometric twist, AR=10

4) None of the above

darmofal:

1

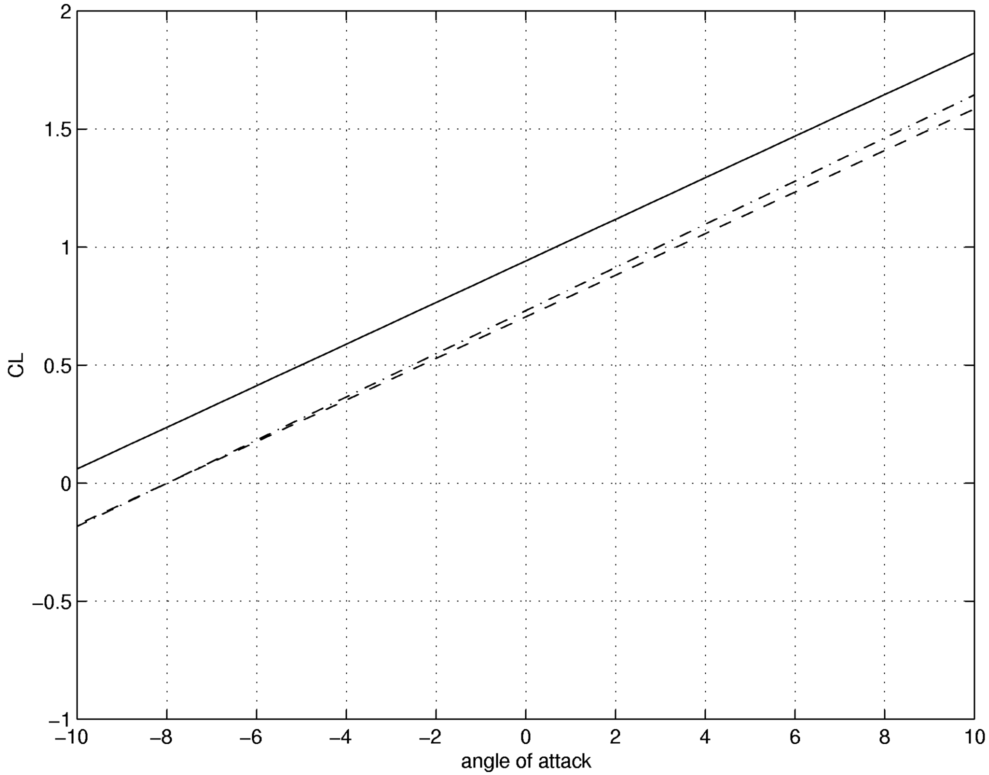


The following results are from a lifting line analysis of three wings **all** with the same airfoil and no geometric twist. Which wing is the **dash-dot line**:

1. Elliptic planform, AR=10
2. Rectangular planform, AR=10
3. Rectangular planform, AR=20
4. None of the above

darmofal:

1



The following results are from a lifting line analysis of three wings **all** with the same airfoil and AR=10. Which wing is the **dash-dot line**:

1. Elliptic planform, no geometric twist.

2. Rectangular planform, no geometric twist

3. Rectangular planform, with geometric twist

4. None of the above

darmofal:

1

Assuming Prandtl's lifting line is being applied:

C_L is at most a linear function of α

(1) True
(2) False
(3) Not enough info

darmofal:

1

Assuming Prandtl's lifting line is being applied:

The span efficiency factor, e, does not change with angle of attack

(1) True

(2) False

(3) Not enough info

darmofal:

1

Assuming Prandtl's lifting line is being applied:

Given a rectangular wing. The wing camber or twist distribution can be designed to provide elliptic lift.

(1) True

(2) False

(3) Not enough info

darmofal:

2

At its cruise flight speed, V_c, a general aviation aircraft has a drag polar which is well approximated by:

$$C_D \cong C_{D_0} + KC_L^2$$

During approach for landing (though still far from the ground), the velocity is about $\frac{1}{2}V_c$. Which do you think is most likely to be true:

(1) Approach Drag < Cruise Drag

(2) Approach Drag > Cruise Drag

(3) Approach Drag ≈ Cruise Drag

darmofal:

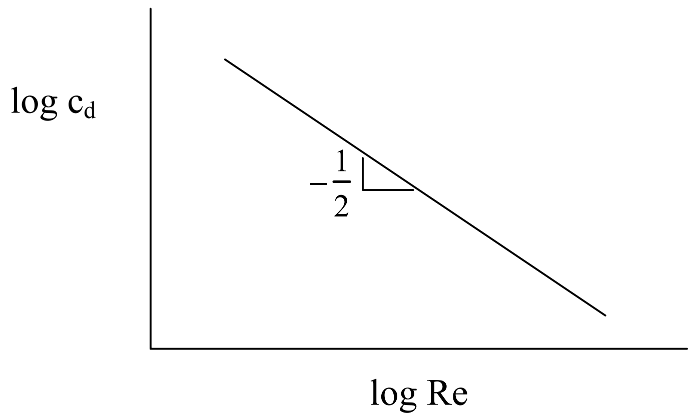
2

As an aircraft nears the ground, the induced drag tends to:

(1) Increase

(2) Decrease

An airfoil has the following C_d vs. Re



At $V_\infty = V_1$, the drag on the airfoil is D'_1 .

For $V_\infty = 2V_1$, the drag on the airfoil is D'_2 .

(1) $D'_1 > D'_2$

(2) $D'_1 = D'_2$

(3) $D'_1 < D'_2$

(4) Not enough info

darmofal:

3

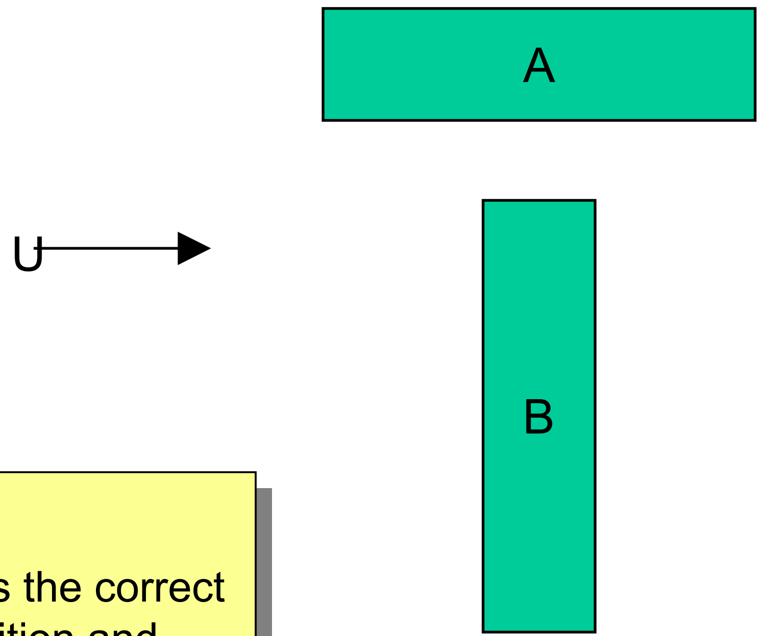
Given two identical flat plates at zero angle of attack and oriented as shown, which of the following is true

(1) Drag A > Drag B

(2) Drag A < Drag B

(3) Drag A = Drag B

(4) Not enough information



darmofal:

When only laminar flow is considered, then 2 is the correct answer. However, if the possibility of transition and turbulence is included, than 4 is correct.

Consider the flow over two thin, uncambered airfoils. The only difference between the airfoils is that the chord of Airfoil A is twice the chord of Airfoil B. Assume the boundary layers on these airfoil are laminar. Which is most likely true for the thickness of the boundary layer at the trailing edge of these airfoils when they are in the same air stream.

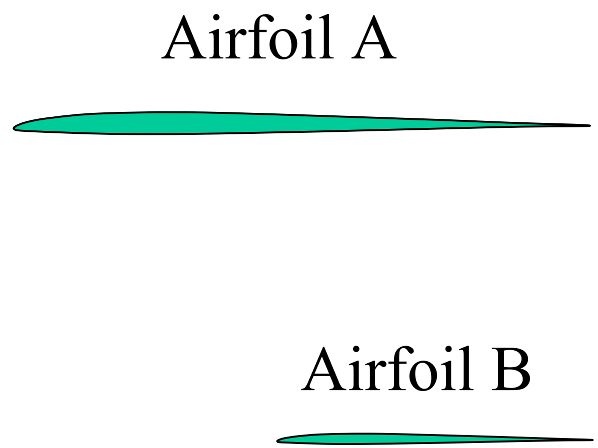
(1) $\delta_A \approx 2\delta_B$

(2) $\delta_A \approx 1.4\delta_B$

(3) $\delta_A \approx \delta_B$

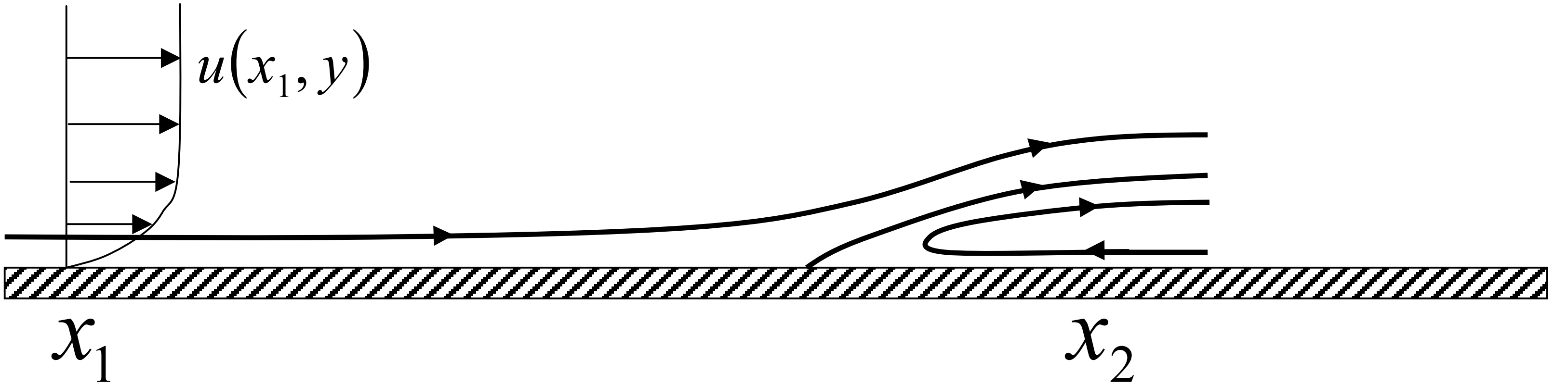
(4) $\delta_A \approx \dfrac{1}{1.4}\delta_B$

(5) $\delta_A \approx \dfrac{1}{2}\delta_B$



darmofal:

2



(1) $c_f(x_2) < 0$

(2) $c_f(x_2) > 0$

(3) Not enough info

darmofal:

1

If the edge pressure is constant for the boundary layer sketched above, what is the direction of the net x-force acting on the fluid element:

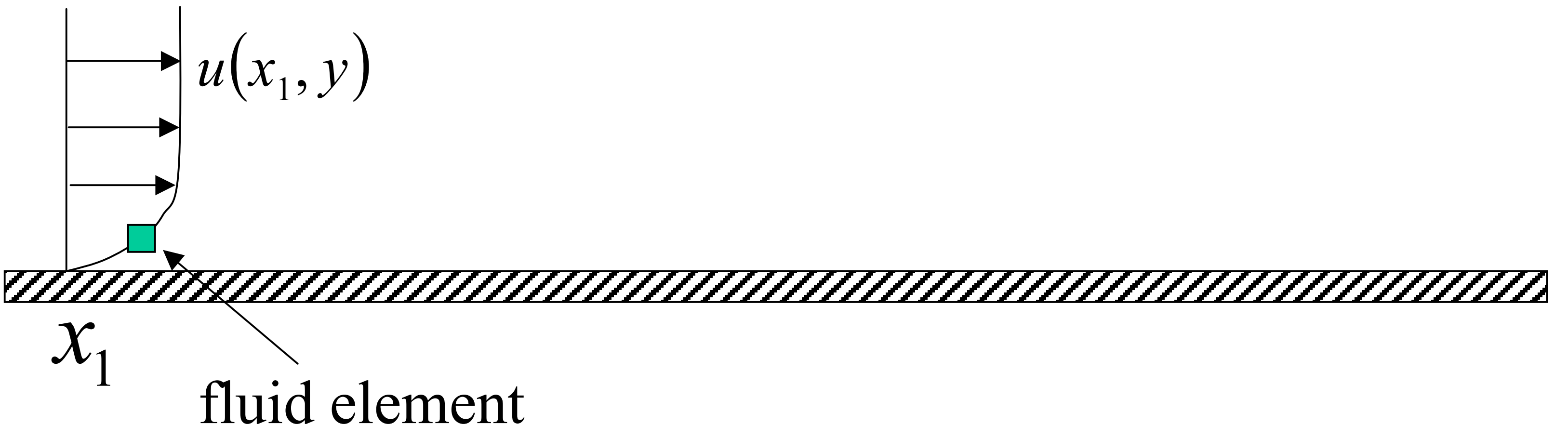
(1) Positive x (to the right)

(2) Negative x (to the left)

(3) Not enough info

darmofal:

2



If the edge pressure is decreasing for the boundary layer sketched above, what is the direction of the net x-force acting on the fluid element:

(1) Positive x (to the right)

(2) Negative x (to the left)

(3) Not enough info

darmofal:

3

If the edge pressure is increasing for the boundary layer sketched above, what is the direction of the net x-force acting on the fluid element:

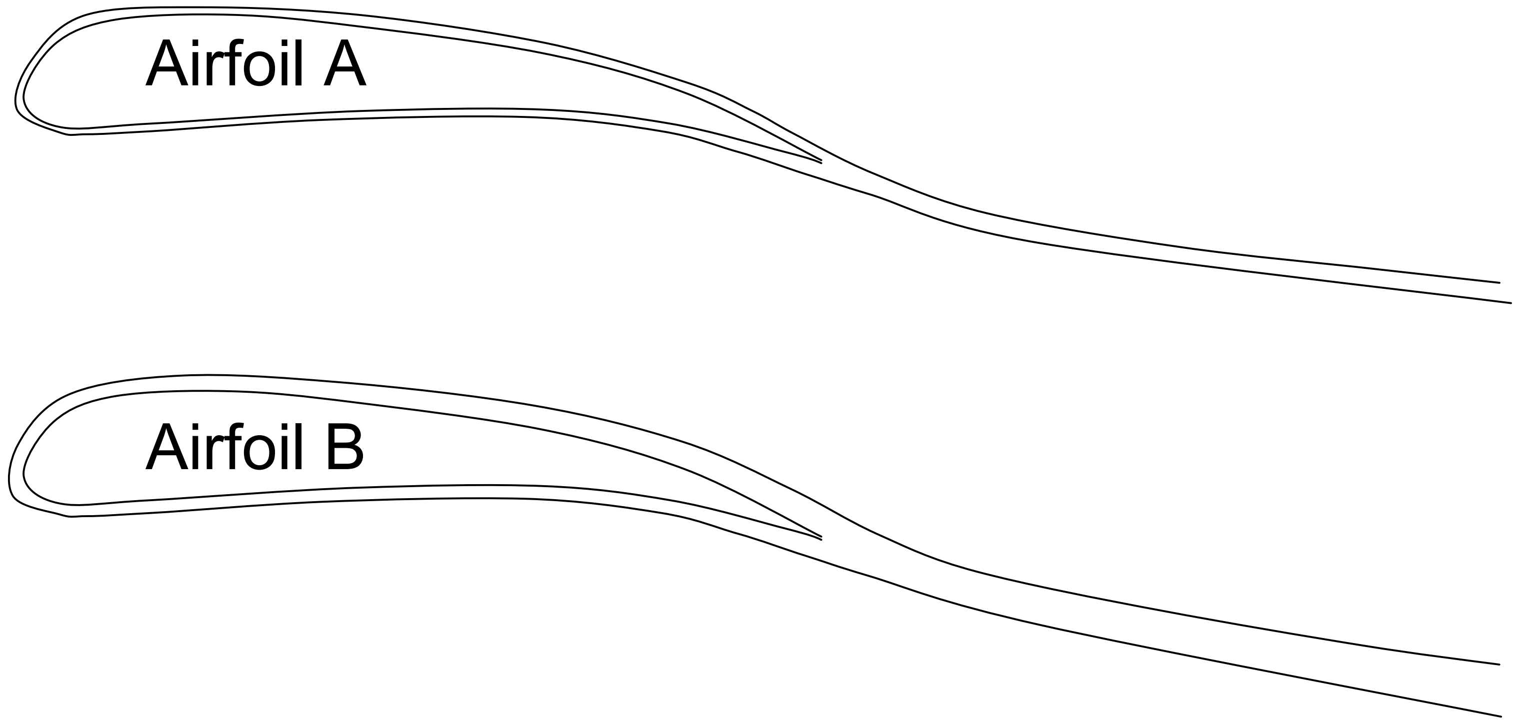
(1) Positive x (to the right)

(2) Negative x (to the left)

(3) Not enough info

darmofal:

2



Consider the pressure distribution on the airfoils for the boundary layers sketched above. Which airfoil's pressure distribution will be most similar to the inviscid flow pressure distribution over the airfoil:

(1) Airfoil A

(2) Airfoil B

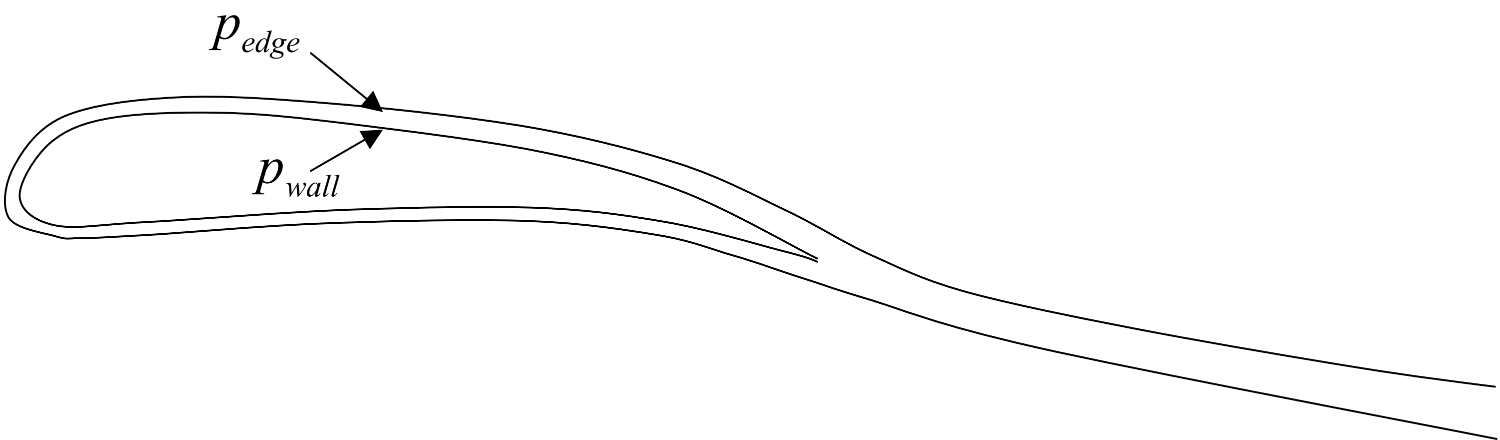
(3) Not enough information

darmofal:

1

darmofal:

2



Which is most likely true:

(1) $p_{edge} < p_{wall}$

(2) $p_{edge} \approx p_{wall}$

(3) $p_{edge} > p_{wall}$

darmofal:

1

Assume that the boundary layer on an airfoil is attached and laminar. Which is most likely to be true:

(1) The skin friction is largest at the leading-edge and decreases toward the trailing edge

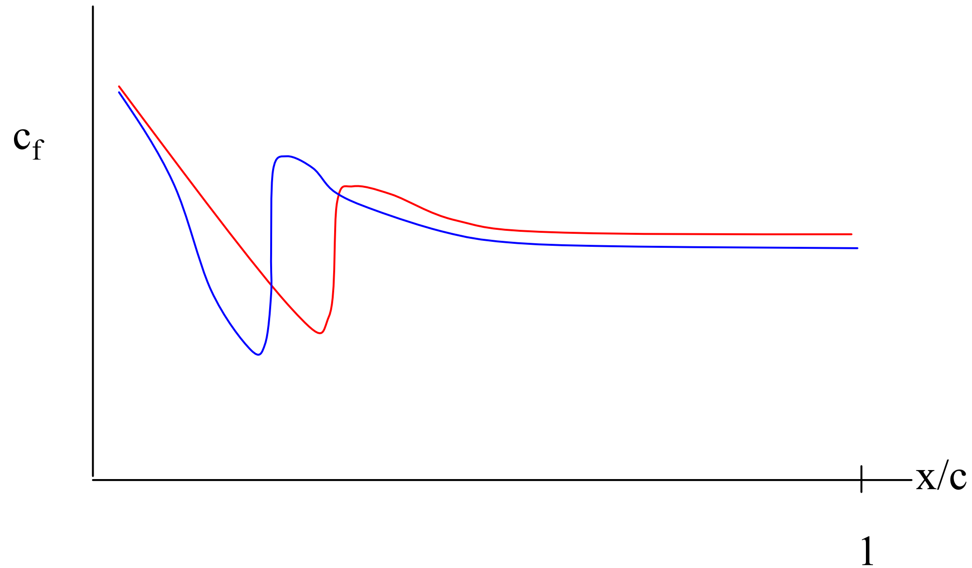
(2) The skin friction is smallest at the leading-edge and increases toward the trailing edge

(3) The skin friction is largest near the location of maximum camber

darmofal:

1

The skin friction coefficient on a symmetric airfoil at V_∞ & $2V_\infty$ are shown below:



Which is true:

(1) The red curve is for $V = V_\infty$

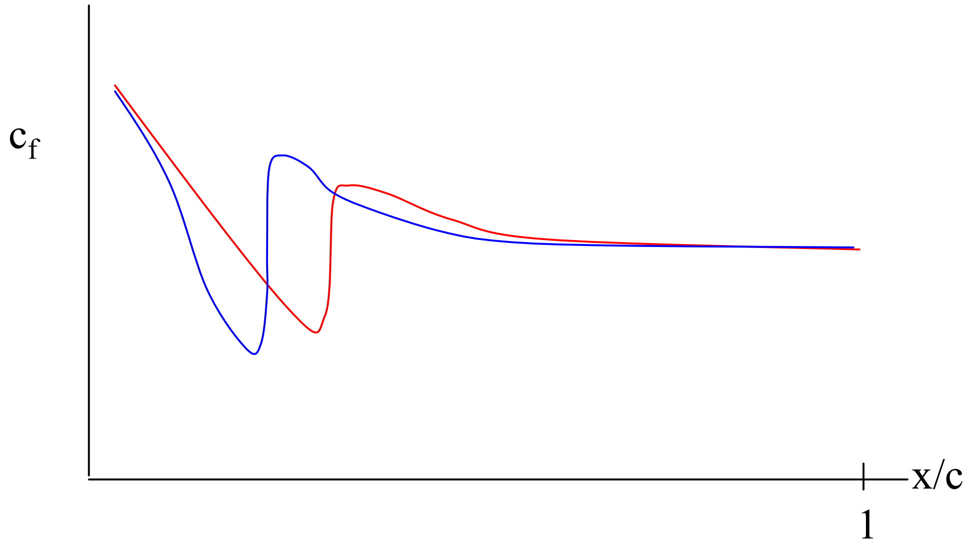
(2) The red curve is for $V = 2V_\infty$

(3)Not enough info

darmofal:

1

The skin friction coefficient on two symmetric airfoils with chords c_0 & $2\,c_0$ from a wind tunnel test at the same velocity is:



Which is true:

(1) The red curve is for the airfoil with $c = c_0$

(2) The red curve is for the airfoil with $c = 2\,c_0$

(3) Not enough info

darmofal:

6

Which are true:

(1) A separated flow must be turbulent.

(2) A turbulent flow must be separated.

(3) If the boundary layer thickness of an attached flow increases along the airfoil surface, the skin friction decreases.

(4) All of the above.

(5) 1 and 2.

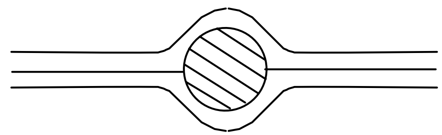
(6) None of the above.

darmofal:

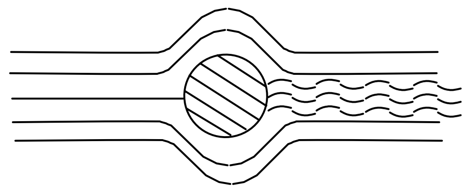
4

Given a cylinder at two different flow conditions

(a) Re $\approx 10^{\circ}$



(b) Re $\approx 10^{7}$



Which of the following is true:

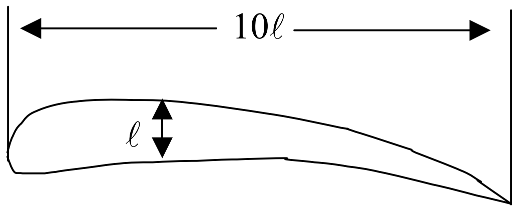
(1) Drag A > Drag B

(2) Drag A < Drag B

(3) Drag A = Drag B

(4) Not enough info

If the airfoil and cylinder are moving with speed V_∞ in air at sea level conditions such that $M_\infty \cong 0.1$ and $\frac{V_\infty \ell}{V_\infty} \cong 10^7$. If the drag per unit length of the cylinder is 10 lb/ft and the airfoil is at approximately zero degrees angle of attack.



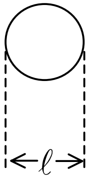
(1) $D'_{airfoil} \approx 0.1\ lb/ft$

(2) $D'_{airfoil} \approx 1\ lb/ft$

(3) $D'_{airfoil} \approx 10\ lb/ft$

(4) $D'_{airfoil} \approx 20\ lb/ft$

(5) $D'_{airfoil} \approx 100\ lb/ft$



darmofal:

2

For the flow of an ideal gas, the total pressure, P_0, and the static pressure, p, are related by:

1) $P_0 = p + \frac{1}{2}\rho\left|\vec{V}\right|^2$

2) $P_0 = p\left(1 + \frac{\gamma - 1}{2}M^2\right)^{\gamma/(\gamma-1)}$

3) Both 1) and 2)

4) Neither

darmofal:

2

darmofal:

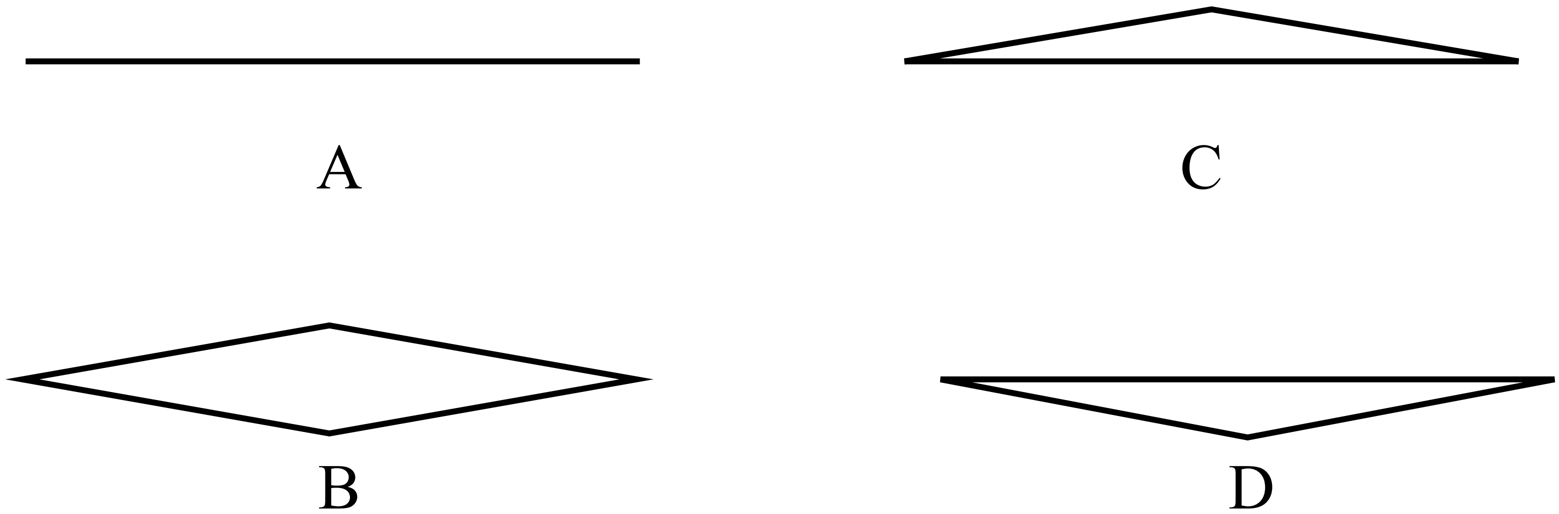
1

For a fixed Mach number and a fixed lift coefficient, the wave drag on a well-designed airfoil in transonic flow will likely:

(1) Increase with increasing thickness

(2) Decrease with increasing thickness

(3) Not enough info



At a positive angle of attack, which is true according to supersonic linearized flow theory:

1) $c_{l_B} > c_{l_A}$

2) $c_{l_C} > c_{l_A}$

3) $c_{l_D} > c_{l_A}$

4) All of the above

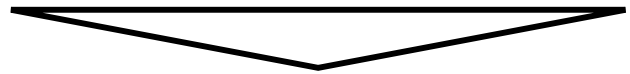
5) None of the above

darmofal:

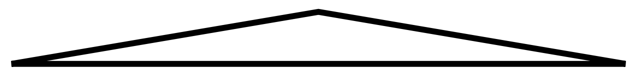
5

darmofal:

1



A



B

In a supersonic flow, at zero angle of attack, which of these airfoils generates positive lift:

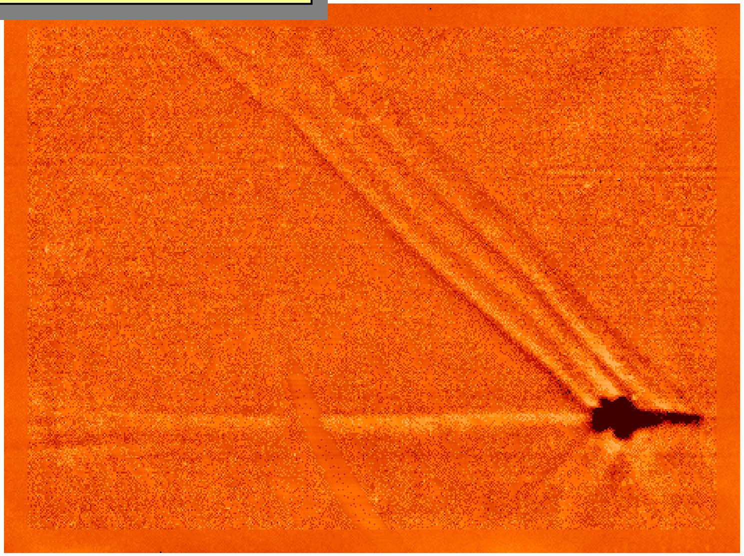
1) Airfoil A

2) Airfoil B

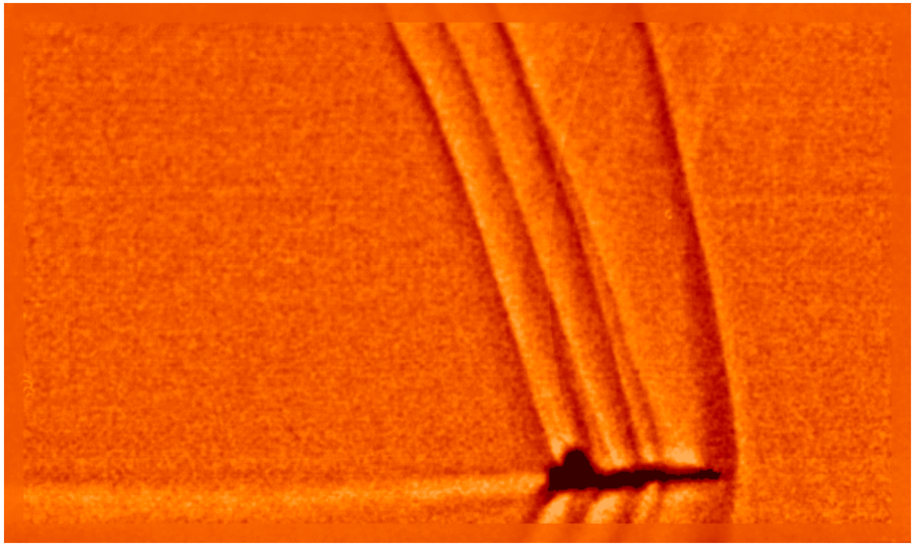
3) Neither airfoil

darmofal:

1



A



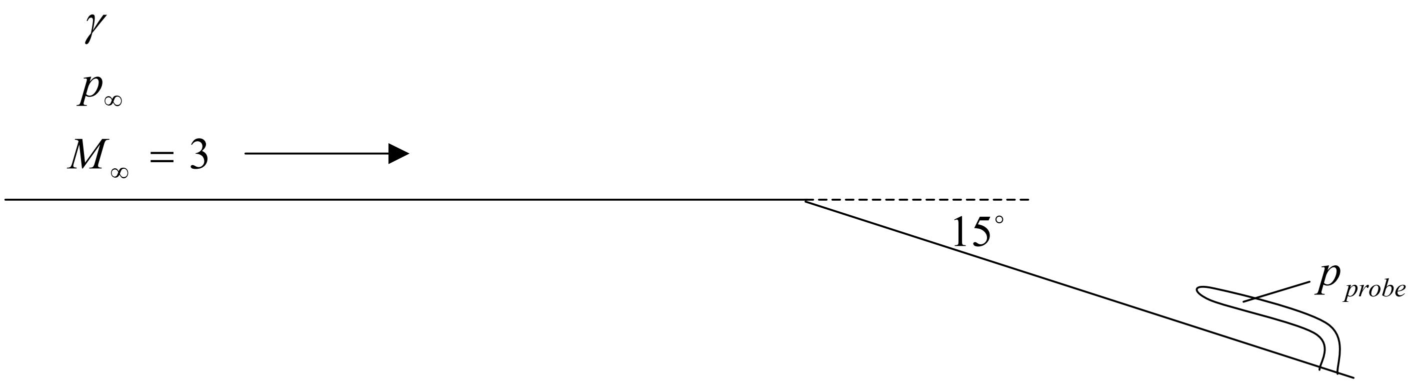
B

Which plane is flying at the higher Mach number:

1) Plane A

2) Plane B

darmofal:
1



A pitot tube is used to measure pressure downstream of the ramp shown above. Approximately, what will the probe pressure be:

(1) $$p_{probe} < p_\infty \left(1 + \frac{\gamma - 1}{2} M_\infty^2\right)^{\gamma/(\gamma-1)}$$

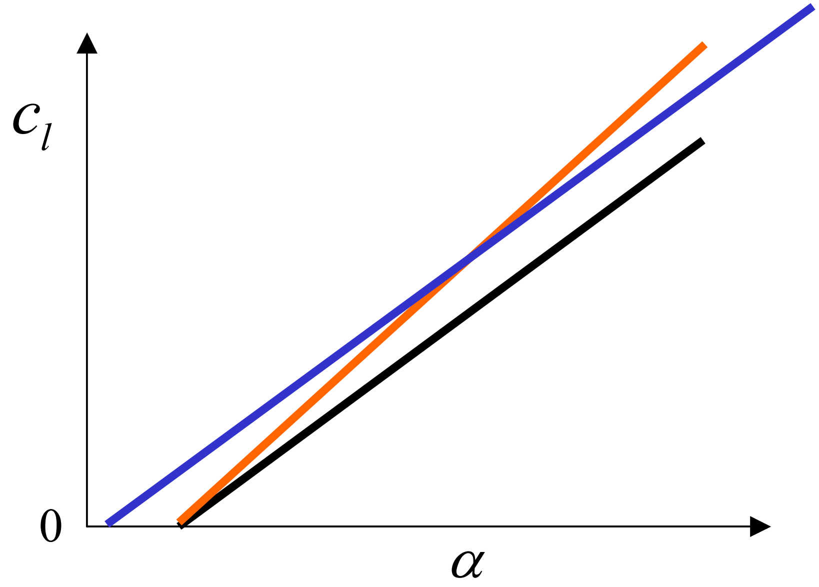
(2) $$p_{probe} = p_\infty \left(1 + \frac{\gamma - 1}{2} M_\infty^2\right)^{\gamma/(\gamma-1)}$$

(3) $$p_{probe} > p_\infty \left(1 + \frac{\gamma - 1}{2} M_\infty^2\right)^{\gamma/(\gamma-1)}$$

(4) Not enough information

darmofal:

2



The above results are from a small disturbance, potential flow analysis of an airfoil under three conditions. Which is the **red line**:

1) Mach = 0.05

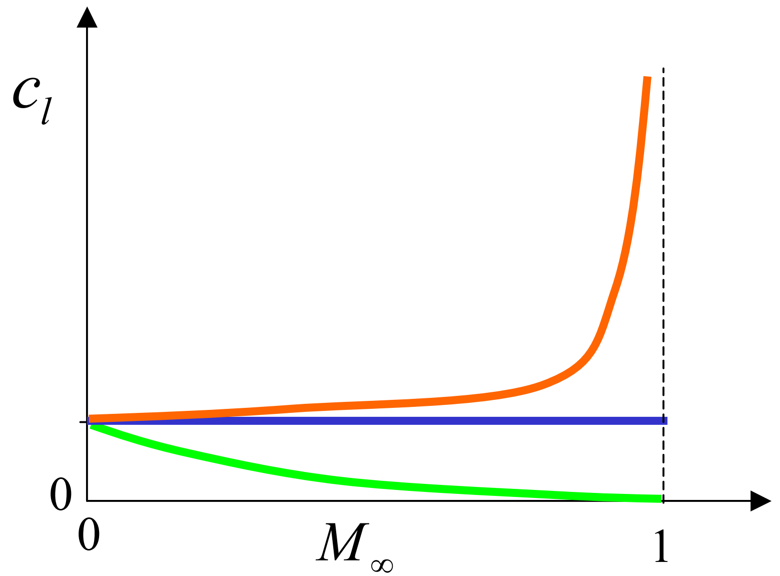
2) Mach = 0.30

3) Mach = 0.05, with a trailing edge flap deflected

4) None of the above

darmofal:

2



The above is a plot of the lift coefficient of an airfoil versus Mach number at a fixed angle of attack. Which line is the result of small disturbance potential flow theory:

1) **Blue line**

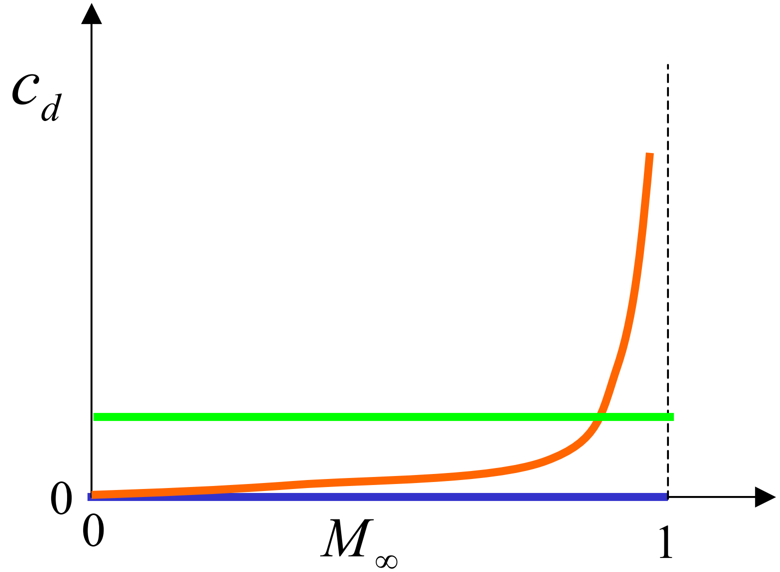
2) **Red line**

3) **Green line**

4) None of the above

darmofal:

1



The above is a plot of the drag coefficient of an airfoil versus Mach number at a fixed angle of attack. Which line is the result of small disturbance potential flow theory:

1) **Blue line**

2) **Red line**

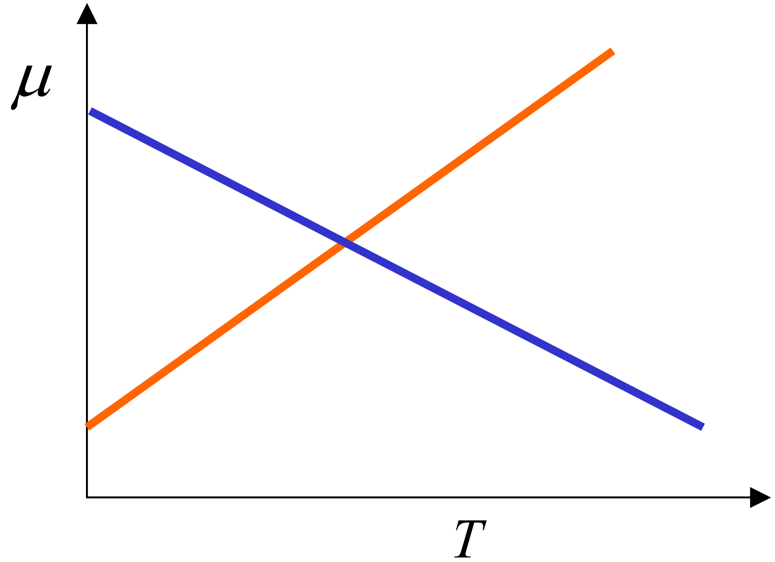
3) **Green line**

4) None of the above

The following concepts were not covered this semester (Fall 2005) and will not be assessed in exams

darmofal:

2



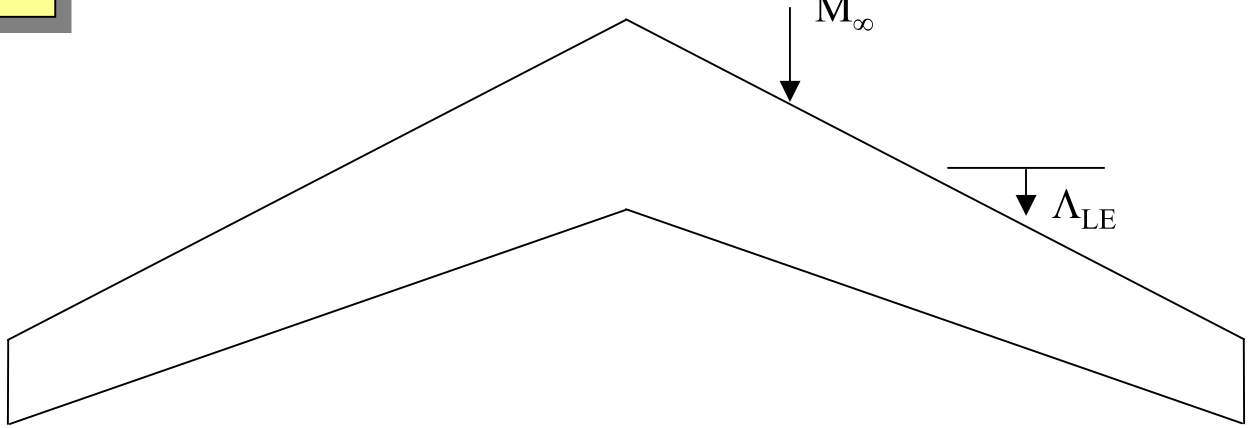
Which trend do you think is most realistic for air:

1) The **blue** line (dynamic viscosity decreases with temperature)

2) The **red** line (dynamic viscosity increases with temperature)

darmofal:

1



Given a swept, high *AR* wing, at fixed α:

(1) M_{crit} increases with Λ_{LE}

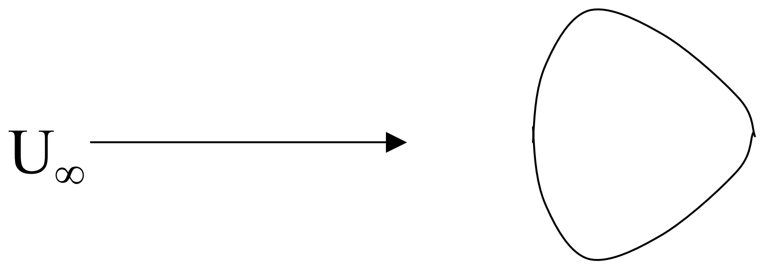
(2) M_{crit} decreases with Λ_{LE}

(3) M_{crit} is independent of Λ_{LE}

(4) Not enough info

darmofal:
2

ncern in the design of vehicles for re-entry in Earth's atmosphere is heating. Often, blunt body shapes are used such as:



Which of the following is true:

(1) Everything else being the same, a laminar boundary layer will tend to decrease the heat transfer to the vehicle at its base

(2) Everything else being the same, a turbulent boundary layer will tend to increase the heat transfer to the vehicle at its base

(3) Not enough information