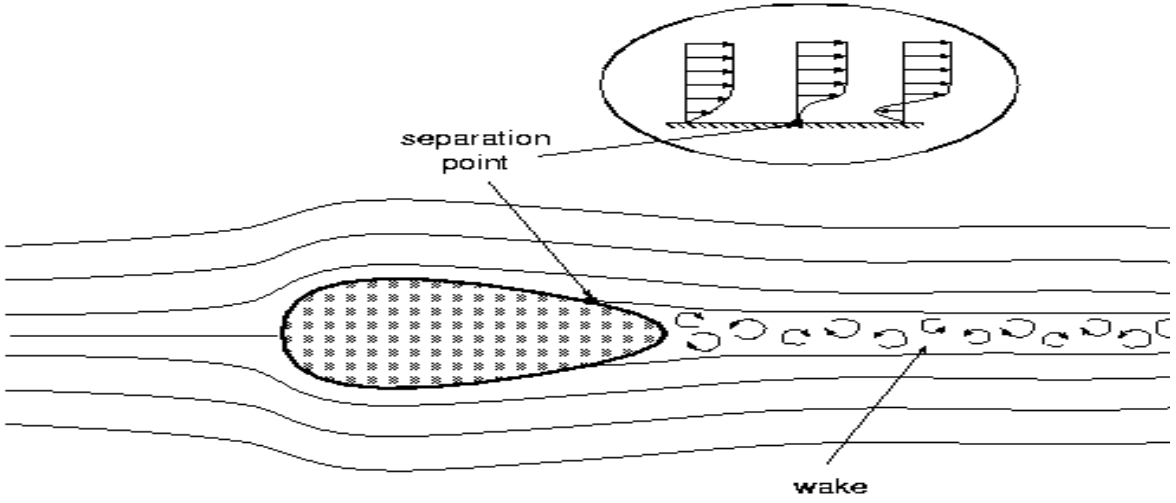
FLUID MECHANICS FOR MECHANICAL ENGINEERING (ME 208F)

Section D:
Boundary Layer Flow - III

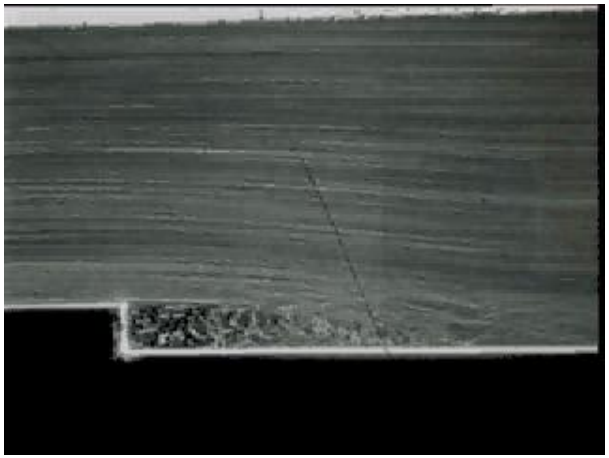
Flow separation

- Flow separation occurs when:
  - the velocity at the wall is zero or negative and an inflection point exists in the velocity profile,
  - and a positive or adverse pressure gradient occurs in the direction of flow.



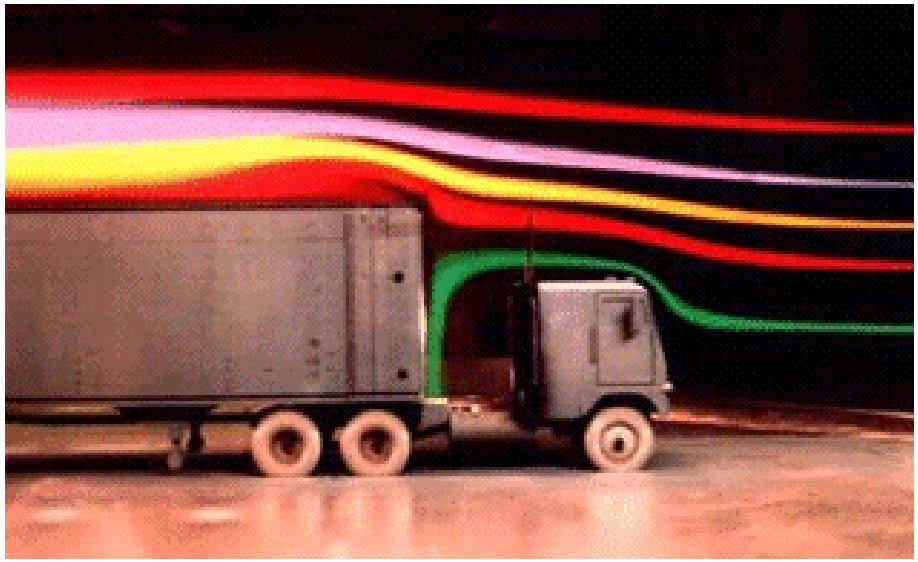
Separation at sharp corners

- Corners, sharp turns and high angles of attack all represent sharply decelerating flow situations where the loss in energy in the boundary layer ends up leading to separation.
- Here we see how the boundary layer flow is unable to follow the turn in the sharp corner (which would require a very rapid acceleration), causing separation at the edge and recirculation in the aft region of the backward facing step.

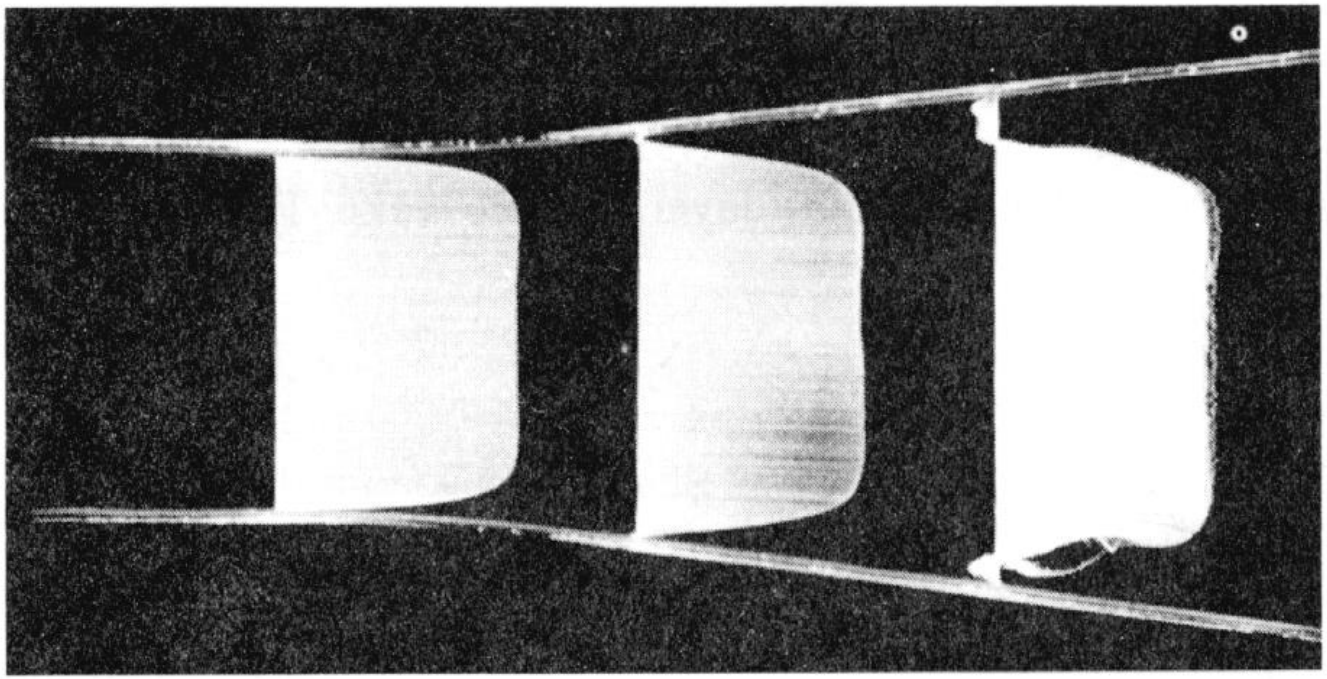


Flow around a truck

- Flow over non-streamlined bodies such as trucks leads to considerable drag due to recirculation and separation zones.
- A recirculation zone is clear on the back of the cab, and another one around the edge of the trailer box.
- The addition of air shields to the cab roof ahead of the trailer helps organize the flow around the trailer and minimize losses, reducing drag by up to 10-15%.

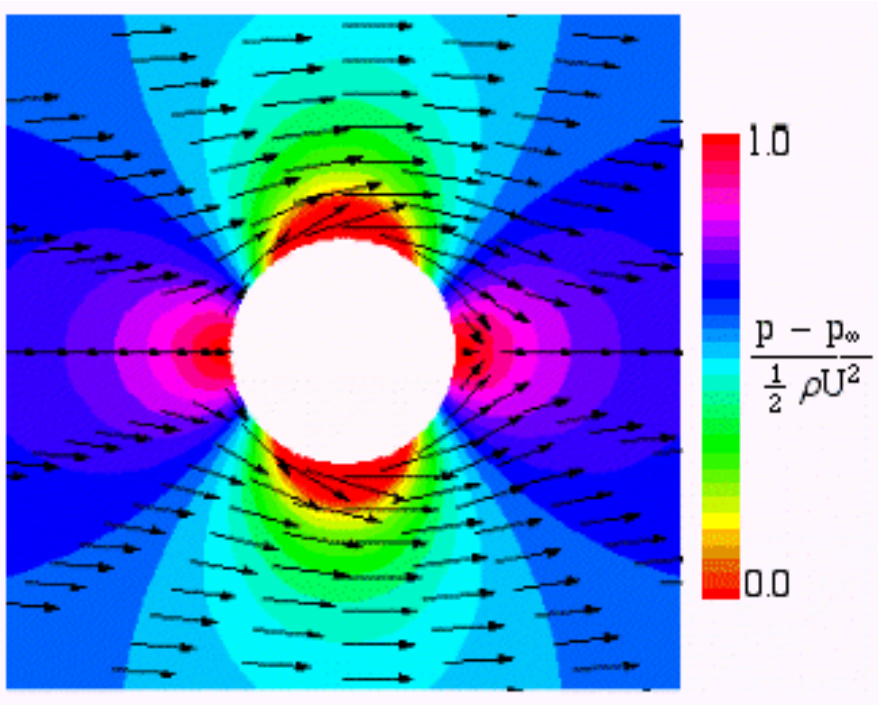


Flow separation in a diffuser with a large angle



Inviscid flow around a cylinder

- The origins of the flow separation from a surface are associated with the pressure gradients impressed on the boundary layer by the external flow.
- The image shows the predictions of inviscid, irrotational flow around a cylinder, with the arrows representing velocity and the color map representing pressure.
- The flow decelerates and stagnates upstream of the cylinder (high pressure zone).
- It then accelerates to the top of the cylinder (lowest pressure).



- Next it must decelerate against a high pressure at the rear stagnation point.