Virtausmekaniikka II (osa B): Tentin kysymyspaketti

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Kysymykset muokattu lähteen pohjalta: Frank M. White, Fluid Mechanics, 7. painos SI yksiköissä, McGraw-Hill, 2011.

1. How do you *recognize* a boundary layer? Cite some physical properties and some measurements that reveal appropriate characteristics.
2. The Reynolds number for transition to turbulence in pipe flow is about $\mathrm{Re}_{tr} \approx 2300$, whereas in flat-plate flow $\mathrm{Re}_{tr} \approx 1 \times 10^6$, nearly three orders of magnitude higher. What accounts for the difference?
3. Without writing any equations, give a verbal description of boundary layer displacement thickness.
4. Describe, in words only, the basic ideas behind the „boundary layer approximations".
5. What is an *adverse* pressure gradient? Give three examples of flow regimes where such gradients occur.
6. What is a *favorable* pressure gradient? Give three examples of flow regimes where such gradients occur.
7. The drag of an airfoil (Fig. 1) increases considerably if you turn the sharp edge around 180° to face the stream. Can you explain this?
8. In Figure 2, the drag coefficient of a spruce tree decreases sharply with wind velocity. Can you explain this?
9. Thrust is required to propel an airplane at a finite forward velocity. Does this imply an energy loss to the system? Explain the concept of thrust and drag in terms of the first law of thermodynamics.
10. How does the concept of *drafting*, in automobile and bicycle racing, apply to the material studied in chapter 7 Flow Past Immersed Bodies?

11. The circular cylinder of Fig. 3 is doubly symmetric and therefore should have no lift. Yet a lift sensor would definitely reveal a finite root-mean-square value of lift. Can you explain this behavior?

12. Explain in words why a thrown spinning ball moves in a curved trajectory. Give some physical reasons why a side force is developed in addition to the drag.

13. Jane wants to estimate the drag coefficient of herself on her bicycle. She has measured the projected frontal area and the rolling resistance as well as the mass of the bike and herself. What else should be measured? How would you estimate the aerodynamic drag coefficient C_D of the rider and bicycle combination?

14. Notice from Fig. 4 that (a) water and mercury and (b) aluminum and steel have nearly the same speeds of sound, yet the second of each pair of materials is much denser. Can you explain this oddity? Can molecular theory explain it?

15. When an object approaches you at $\mathrm{Ma} = 0{,}8$, you can hear it, according to Fig. 5. But would there be a Doppler shift? For example, would a musical tone seem to you to have a higher or a lower pitch?

16. The subject of this chapter is commonly called *gas dynamics*. But can liquids not perform in this manner? Using water as an example, make a rule-of-thumb estimate of the pressure level needed to drive a water flow at velocities comparable to the sound speed.

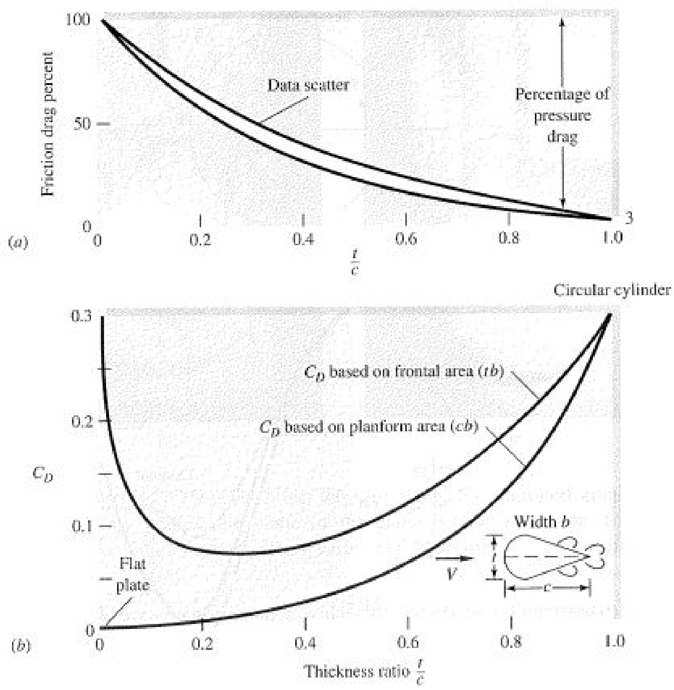
17. Suppose a gas is driven at compressible subsonic speeds by a large pressure drop, p_1 to p_2. Describe its behavior on an appropriately labeled Mollier chart for (a) frictionless flow in a converging nozzle and (b) flow with friction in a long duct.

18. Describe physically what the „speed of sound" represents. What kind of pressure changes occur in air sound waves during ordinary conversation?

19. Give a physical description of the phenomenon of choking in a conversing-nozzle gas flow. Could choking happen even if a wall friction were not negligible?

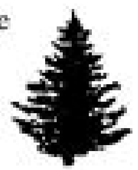
20. Shock waves treated as discontinuities here, but they actually have a very small finite thickness. After giving it some though, sketch your idea of the distribution of gas velocity, pressure, temperature, and entropy though the inside of a shock wave.

21. Describe how an observer, running along a normal shock wave at finite speed V, will see what appears to be an oblique shock wave. Is there any limit to the running speed?



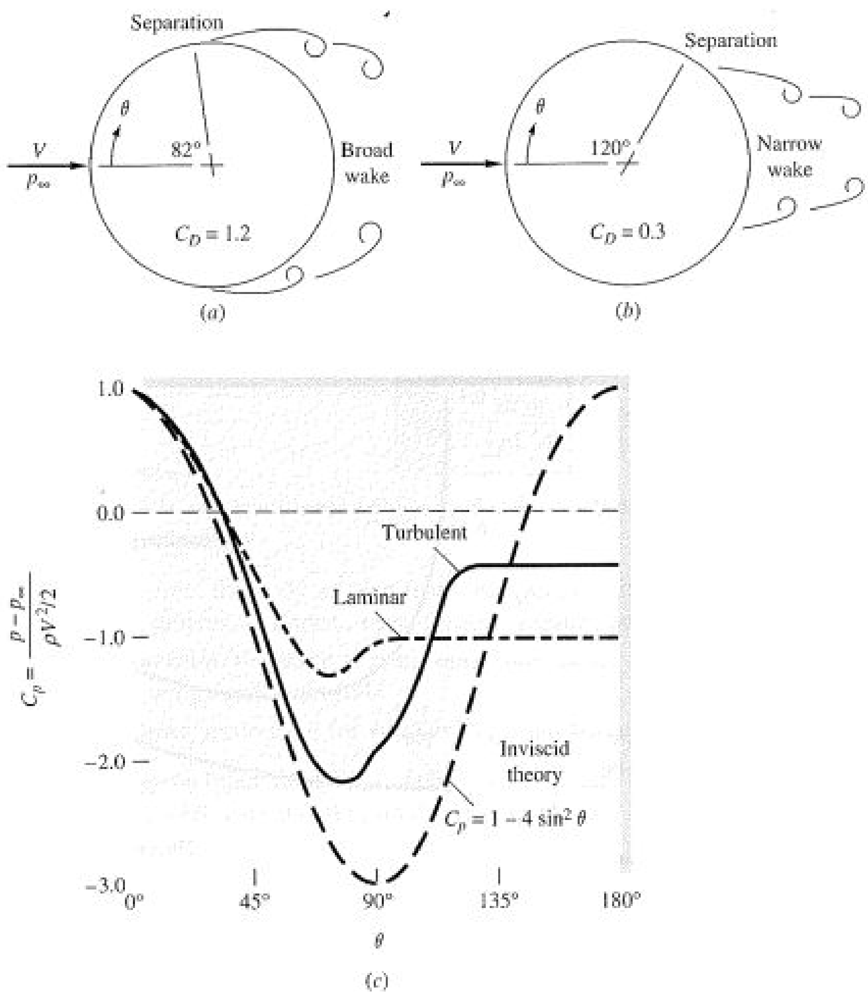
Kuva 1: Drag of a streamlined two-dimensional cylinder at $\mathrm{Re}_c = 10^6$: (a) effect of thickness ratio on percentage of friction drag; (b) total drag versus thickness when based on two different areas.

Pine and spruce trees [24]:



U, m/s:	10	20	30	40
C_D:	1.2 ± 0.2	1.0 ± 0.2	0.7 ± 0.2	0.5 ± 0.2

Kuva 2: Drag of three-dimensional bodies at $\mathrm{Re} \geq 10^4$

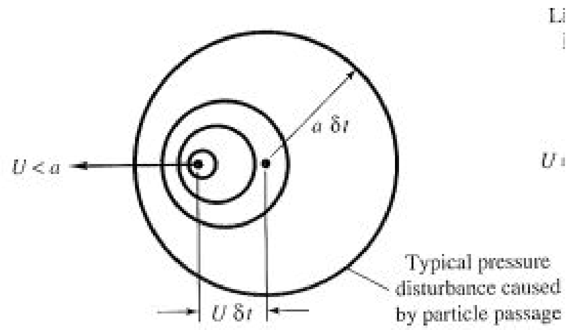


Kuva 3: Flow past a circular cylinder: (a) laminar separation; (b) turbulent separation; (c) theoretical and actual surface pressure distributions

Material	a, m/s
Gases:	
H_2	1,294
He	1,000
Air	340
Ar	317
CO_2	266
CH_4	185
$^{238}UF_6$	91
Liquids:	
Glycerin	1,860
Water	1,490
Mercury	1,450
Ethyl alcohol	1,200
Solids:*	
Aluminum	5,150
Steel	5,060
Hickory	4,020
Ice	3,200

*Plane waves. Solids also have a *shear-wave speed*.

Kuva 4: Sound Speed of Various Materials at 15,5°C and 1 atm



Kuva 5: Wave patterns set up by a particle moving at speed U into still fluid of sound velocity a: subsonic motion.