Fluid mechanics

Instruction 7

Week 7

Van onderstaande vraagstukken zal tijdens de instructie er een aantal behandeld worden. Het is een goede voorbereiding er doorheen te kijken, en te proberen of je ze zelf kan oplossen.

Let op: vraagstuknummering is niet altijd uniform door de verschillende edities van 'White'.

Bron: alle opgaven komen van het boek *Fluid Mechanics* van Frank M. White (McGraw-Hill Series in Mechanical Engineering)

Grenslagen

P7.36 A ship is 125 m long and has a wetted area of 3500 m^2. Its propellers can deliver a maximum power of 1.1 MW to seawater at 20°C. If all drag is due to friction, estimate the maximum ship speed, in kn.

Hint: Een ‘kn’ is uiteraard geen kilo-newton, maar een knot = ‘knoop’.
1 knoop = 1 nmi/hr = 1 nautic mile / hour = 1 zeemijl per uur
1 zeemijl = 10 kabellengtes = 1852 meter.

Aerodynamica

P7.57 The main cross-cable between towers of a coastal suspension bridge is 60 cm in diameter and 90 m long. Estimate the total drag force on this cable in crosswinds of 50 mi/h. Are these laminar-flow conditions?

Hint: ‘landmijl’ is geen ‘zeemijl’, maar slechts 1609 m.

Andere Mijl eenheden:

- Duitse (of geografische) mijl - 7407,41 meter
- Hollandse mijl - 5555,6 meter (1/20 graden)
- Zweedse en Noorse mijl - 10 kilometer
- Spaanse mijl - bijna 7 kilometer
- Oude Romeinse mijl - bijna 2,5 kilometer.

Aerodynamica

Hint: 'standard atmosphere' staat hieronder.
Los de differentiaalvergelijking niet op, maar bepaal (eerst) voor de gemiddelde dichtheid.
Bekijk dat later wel kritisch!

P7.64 A parachutist jumps from a plane, using an 8.5-m-diameter chute in the standard atmosphere. The total mass of the chutist and the chute is 90 kg. Assuming an open chute and quasi-steady motion, estimate the time to fall from 2000- to 1000-m altitude.

***P2.29** Under some conditions the atmosphere is *adiabatic*, $p \approx (\text{const})(\rho^k)$, where k is the specific heat ratio. [redacted] the pressure variation is given by

$$p = p_0\left[1 - \frac{(k-1)gz}{kRT_0}\right]^{k/(k-1)}$$

Compare this formula for air at $z = 5000$ m with the standard atmosphere in Table A.6.

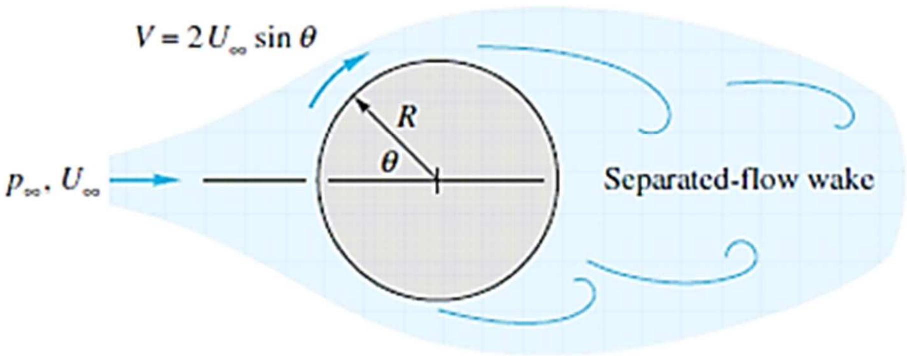
Aerodynamica: de actualiteit!

P7.79 Assume that a radioactive dust particle approximates a sphere of density 2400 kg/m^3. How long, in days, will it take such a particle to settle to sea level from an altitude of 12 km if the particle diameter is (*a*) 1 μm or (*b*) 20 μm?

Hint: ‘standard atmosphere’:
Als in vorige opgave.

Aerodynamica

P7.63 The cross section of a cylinder is shown in Fig. P7.63. Assume that on the front surface the velocity is given by potential theory (Sec. 8.4), $V = 2U_\infty \sin\theta$, from which the surface pressure is computed by Bernoulli's equation. In



the separated flow on the rear, the pressure is assumed equal to its value at $\theta = 90°$. Compute the theoretical drag coefficient and compare with Table 7.2.

Aerodynamica

P7.87 A tractor-trailer truck has a drag-area $C_D A = 8\ m^2$ bare and 6.7 m^2 with an aerodynamic deflector (Fig. 7.18*b*). Its rolling resistance is 50 N for each mile per hour of speed. Calculate the total horsepower required at sea level with and without the deflector if the truck moves at (*a*) 55 mi/h and (*b*) 75 mi/h.

Om van de lastige definitie van 'aanstroomoppervlak' *A* af te komen wordt in de voertuigaerodynamica geregeld het $C_D.A$ product gebruikt.

Aerodynamica

P7.115 An airplane weighs 180 kN and has a wing area of 160 m^2 and a mean chord of 4 m. The airfoil properties are given by Fig. 7.25. If the airplane cruises at 250 mi/h at 3000-m standard altitude, what propulsive power is required to overcome wing drag?

Gasdynamica

P9.19 The Concorde aircraft flies at Ma ≈ 2.3 at 11-km standard altitude. Estimate the temperature in °C at the front stagnation point. At what Mach number would it have a front stagnation-point temperature of 450°C?

De Concorde was de enige supersone lijnvlucht; tussen Parijs/London en New York.
Lees de historie op bijv. http://nl.wikipedia.org/wiki/Concorde_(vliegtuig)

Gasdynamica

P9.33 Air flows isentropically from a reservoir, where $p = 300$ kPa and $T = 500$ K, to section 1 in a duct, where $A_1 = 0.2$ m^2 and $V_1 = 550$ m/s. Compute (*a*) Ma_1, (*b*) T_1, (*c*) p_1, (*d*) $\dot{m}$, and (*e*) A^*. Is the flow choked?

Hint: 'Gasdynamica-sommen' zijn meestal puzzels: Welke parameters ken ik, welke nog niet. Kan ik relateren?
Hier: bepaal eerst uit de energievergelijking, $c_p T + \frac{1}{2} V^2 = \mathrm{Cst}$, de temperatuur T_1

Gasdynamica

P9.52 A converging-diverging nozzle exits smoothly to sea-level standard atmosphere. It is supplied by a 40-m^3 tank initially at 800 kPa and 100°C. Assuming isentropic flow in the nozzle, estimate (*a*) the throat area and (*b*) the tank pressure after 10 s of operation. The exit area is 10 cm^2.

Hint: ‘smooth’ = ‘aangepast’.
Hint 2: de intiële massa in de tank is erg groot t.o.v. 10 seconde leegloop. Check!

Gasdynamica

P9.55 Air, supplied by a reservoir at 450 kPa, flows through a converging-diverging nozzle whose throat area is 12 cm^2. A normal shock stands where $A_1 = 20\ cm^2$. (*a*) Compute the pressure just downstream of this shock. Still farther downstream, at $A_3 = 30\ cm^2$, estimate (*b*) p_3, (*c*) A_3^*, and (*d*) Ma_3.

Ook een typische 'puzzel'. (b..d) zijn lastiger dan je denkt; A_3* is ongelijk aan A*!
Als ná A_3 de diffusor geleidelijk en verliesvrij uitwaaiert naar $reservoir_4$;
schets dan vanaf $reservoir_1$ t/m $reservoir_4$ het verloop van druk en temperatuur.