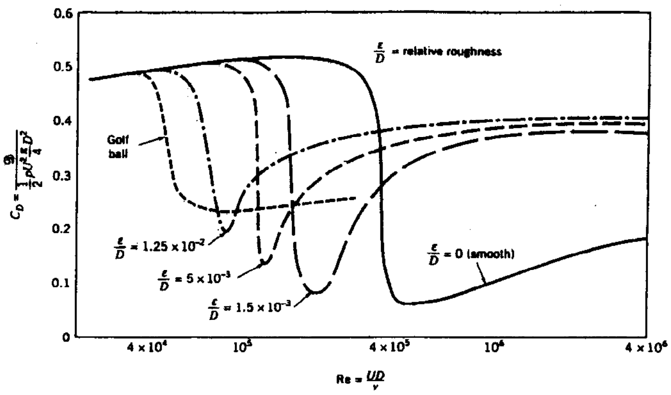
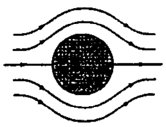
1. The figure shows the variations of the drag coefficients of sphere at different Reynolds number and



surface roughness.

Please answer the followings.

A. Please draw the streamlines of the smooth sphere cross section at Re10^5 and 10^6, respectively.

For example :  (5%)

B. Give the detailed physical reason for the sudden drop of drag coefficients of the smooth sphere at Re=4x10^5.(5%)

C. Explain why the golf ball has a lower drag coefficient at Re=10^5 compared to the smooth sphere. (5%)

2. A thin pancake at 80°C is cooled by an air stream at 20°C with a convective heat transfer coefficient hc=8 W/m^2 · K. The pancake has a thickness and diameter of 0.3 cm and 7.5 cm, respectively.

A. Indicate that whether lump capacitance assumption is valid. (5%)

B. Determine the time for the pancake to cool to 25°C. (10%)

(for pancake k=0.25 W/m · K, C=3000 J/kg · K, ρ=500 kg/m^3).

3 Please answer the followings.

(a) How do oblique shocks occur? How do oblique shocks differ from normal shocks? Does the flow downstream of an oblique shock have to be subsonic? (6%)

(b) Consider subsonic flow in a converging nozzle with fixed inlet conditions. What is the effect of dropping the back pressure to the critical pressure on the exit velocity, the exit pressure, and the mass flow rate through the nozzle? (3%)

(c) Consider a converging nozzle and a converging–diverging nozzle having the same throat areas. For the same inlet conditions, how would you compare the mass flow rates through these two nozzles? (3%)

(d) What would happen if we attempted to decelerate a supersonic fluid with a diverging diffuser? (3%)

4. Consider the sun as a blackbody radiator at 5800 K. The diameter of the sun is approximately 1.39 x 10^9 m, the diameter of the earth is approximately 1.29 x 10^7 m, and the distance between the sun and earth is approximately 1.5 x 10^{11}m. The Stefan-Boltzmann constant σ is 5.67 x 10^{-8}W/m^2 K^4.

(a) Calculate the total energy emitted by the sun in watts. (3%)

(b) Calculate the amount of the sun's energy intercepted by the earth. (3%)

(c) Calculate the solar flux in W/m^2 at the upper reaches of the earth's atmosphere for the sun's rays striking a surface perpendicularly. (3%)

(d) Compare this quantity with the maximum solar flux of 720 W/m^2 recorded during a clear day in Fort Collins, Colorado. Explain the difference. (3%)

(e) The U.S. electricity production for an entire year is 3836.6 x 10^{12} W hr. How many nanoseconds does it take for the sun to emit such an amount of energy? (3%)

5. Assume a cubic polynomial for the velocity profile in the **laminar boundary layer flow** with blowing or suction at the wall ($v_w \neq 0$) as $\frac{u}{U} = a(\frac{y}{\delta}) + b(\frac{y}{\delta})^2 + c(\frac{y}{\delta})^3$, where U is the free stream velocity; and δ is the boundary layer thickness. The Reynolds number for the blowing (or suction), Re^*, is a known parameter ($\mathrm{Re}^* = \rho\delta v_w / \rho$).

(a) What are the boundary conditions and explain their physical meaning. (10%)

(b) Derive the velocity profile (*a=?, b=?, c=?*) according to the boundary conditions. (10%)

6. Derive a **differential equation for the temperature distribution** in a straight triangular fin which is attached to an engine or a CPU at the right hand side as shown in the figure below. (5%) For convenience, take the coordinate axis as indicated in the figure and assume one dimensional heat flow $T=T(x)$ only. Please comment on effects from the convection coefficient h and the thermal conductivity k. (5%) Is it better to place the fin horizontally (as shown in the figure) or vertically? Why? (5%) What are the definitions of Nu and Gr for this convection heat transfer? (5%)