PERPINDAHAN PANAS II

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Laboratorium Efisiensi dan Konservasi Energi

Universitas Diponegoro

Metoda Pengajaran

- Kuliah di kelas
- Tugas/pekerjaan rumah
- Tugas Besar: menyelesaikan masalah dengan FLUENT dan membuat makalah

Penilaian/Assessment

Kuiz	: 10%
PR dan Tugas Kecil	: 15%
Mid Test	: 15%
Ujian Akhir	: 15%
Tugas Besar	: 45%

Persyaratan Penilaian

- ✓ Kehadiran $\geq$ 70 %
- ✓ Harus membuat semua tugas

Ketentuan Lain

- Masuk ruang kuliah maksimum 5 menit setelah Dosen masuk ruang kuliah.

- Peserta kuliah dibagi menjadi kelompok yang terdiri dari 4 orang.

- Setiap mahasiswa harus belajar dan dapat menggunakan software untuk penyelesaian masalah perpindahan kalor secara numerik (numerical heat transfer) yaitu FLUENT/ANSYS dan Solidworks.

Course Contents

1. Introduction
2. Fundamentals of Convection
3. Numerical Heat Transfer
4. External Convection
5. Internal Convection
6. Natural Convection
7. Heat Exchangers
8. Boiling

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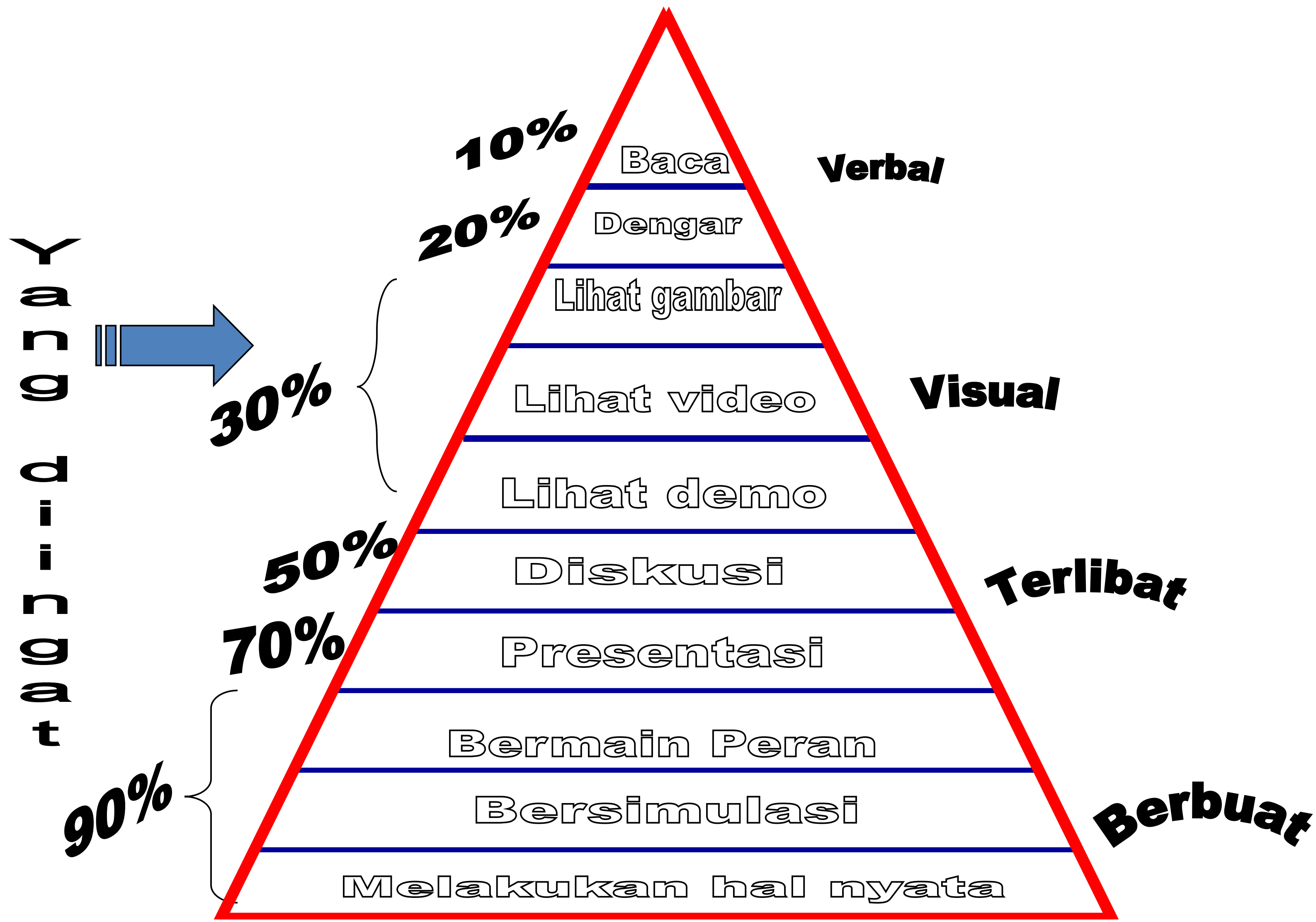
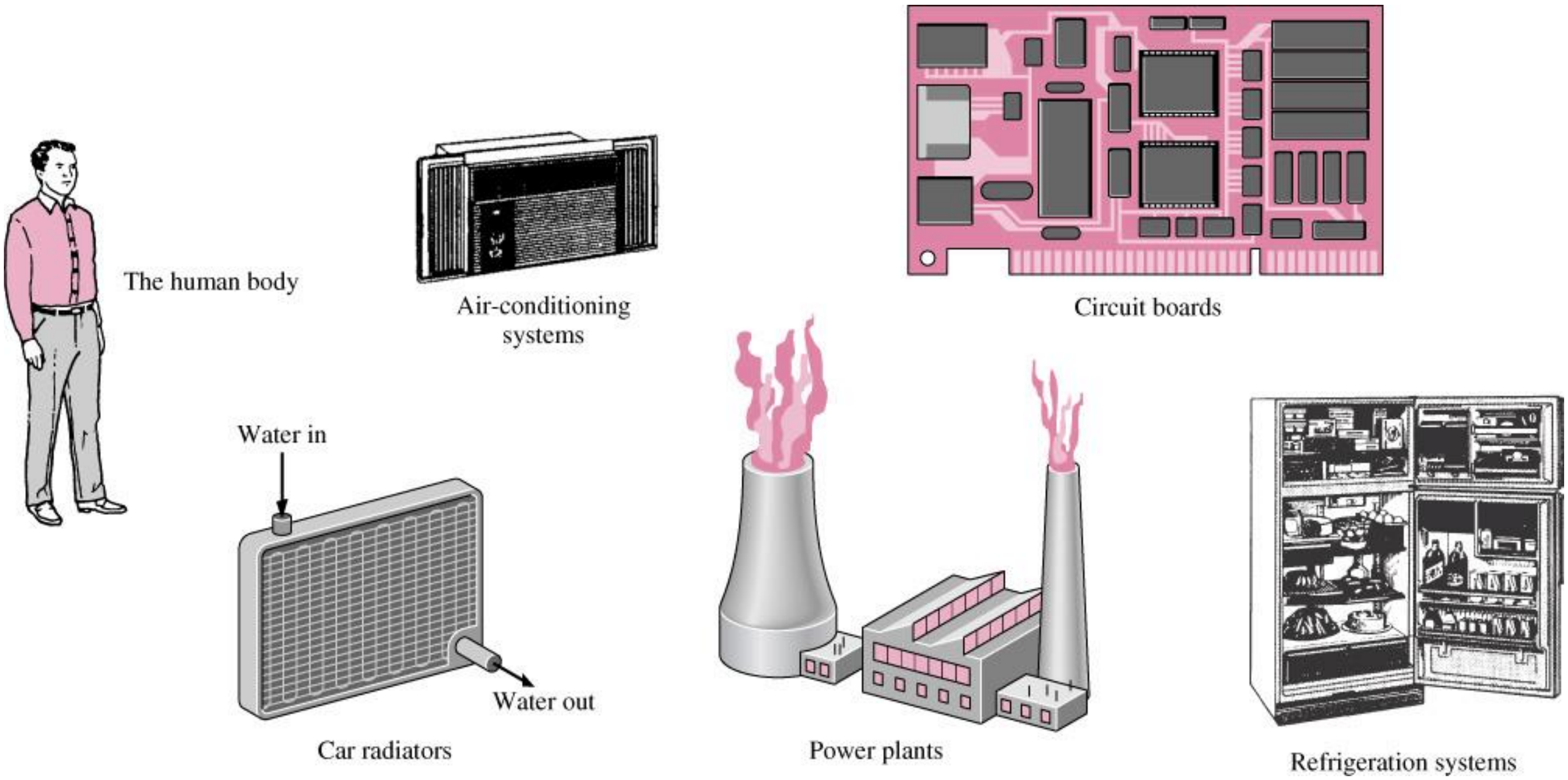
Kerucut Pengalaman Edgar Dale

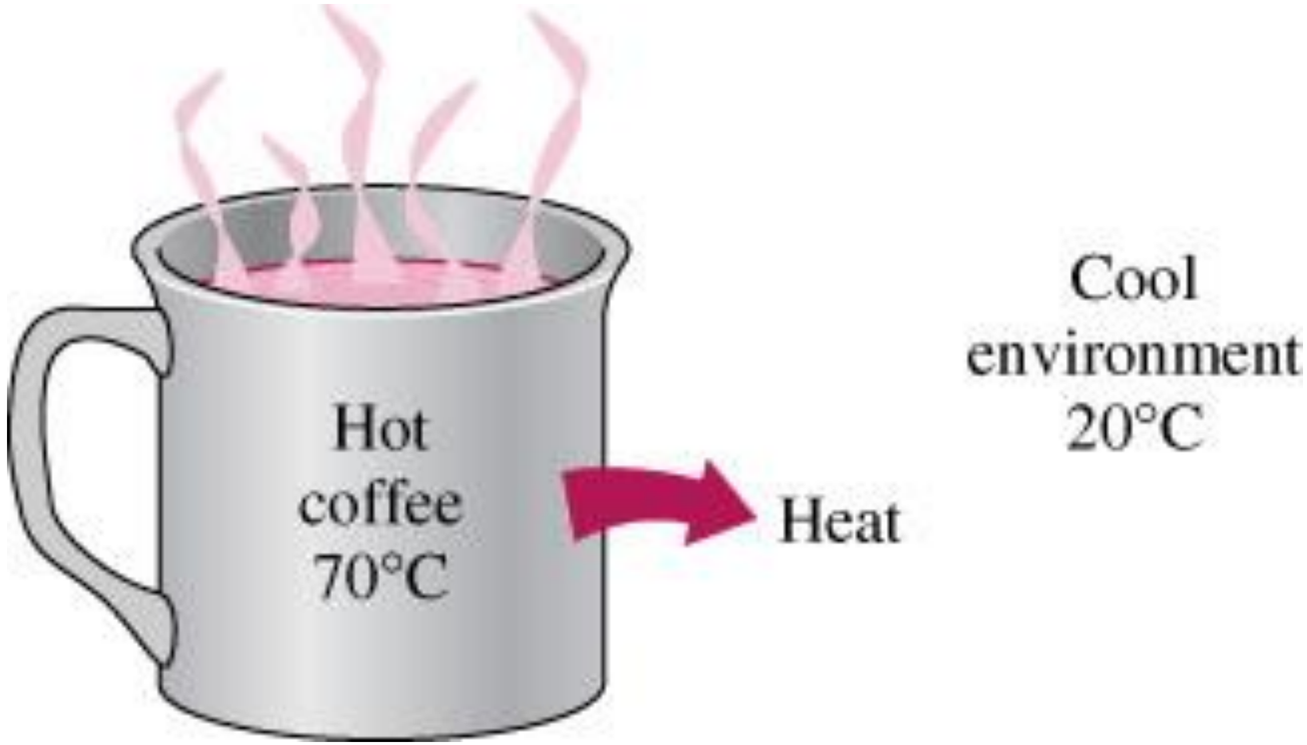


Metoda Belajar Efektif

- ✓ Ingat: ILMU PASTI BERGUNA
- ✓ Kewajiban Manusia: BELAJAR SEPANJANG HAYAT
- ✓ NIKMATILAH PROSES BELAJAR
- ✓ Tirulah anak balita : BANYAK BERTANYA

Heat Transfer Problems





1. Law: Energy conservation – Energy can not be created or destroyed, it can only changes form.
2. Law: Energy has both quality and quantity. The quality of energy can only decrease for a closed system.

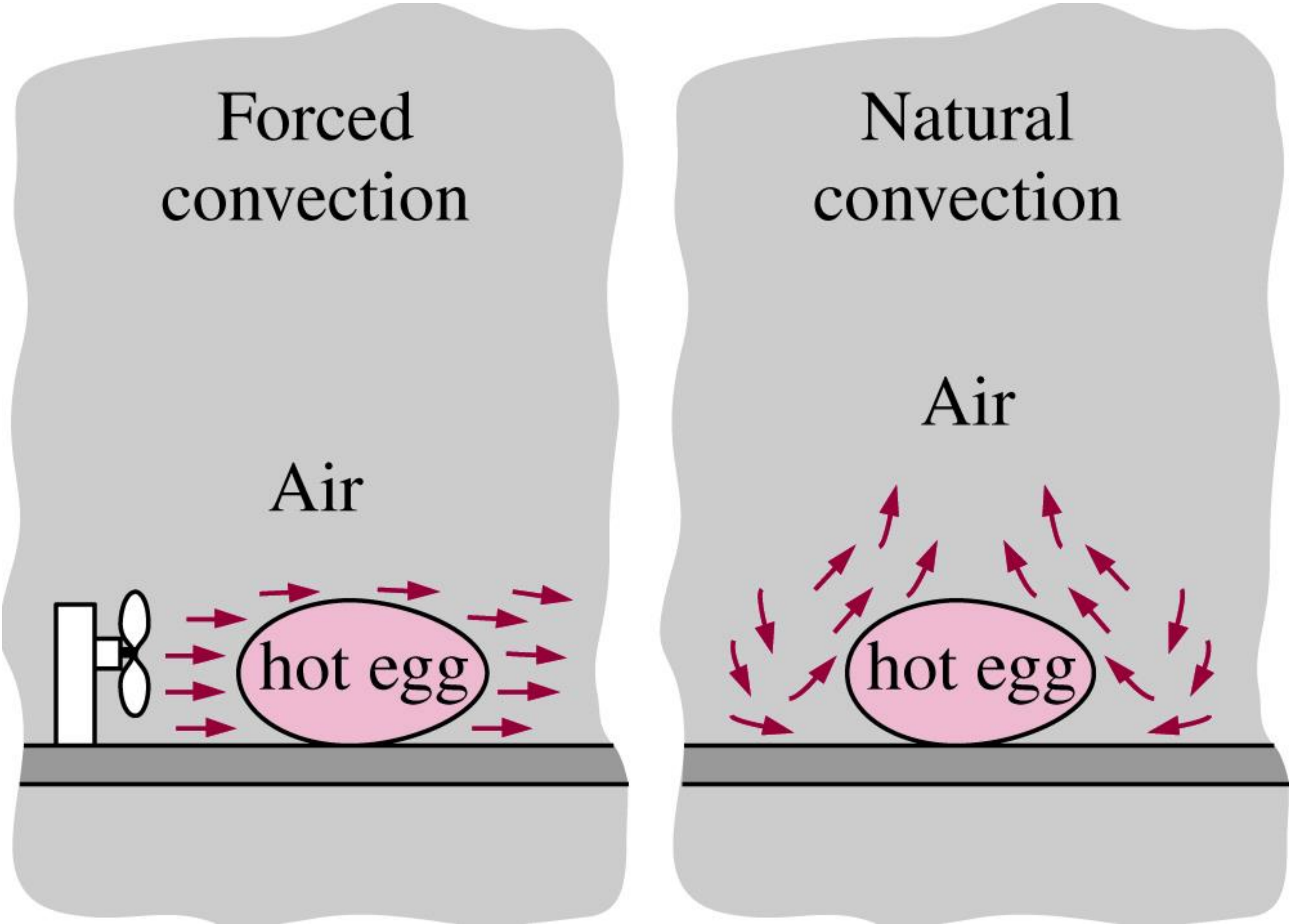
Introduction

- **Convective heat transfer** is a mechanism of **heat transfer** occurring because of bulk motion (observable movement) of fluids.

- This can be contrasted with conductive heat transfer, which is the transfer of energy by vibrations at a molecular level through a solid or fluid, and radiative heat transfer, the transfer of energy through electromagnetic waves.

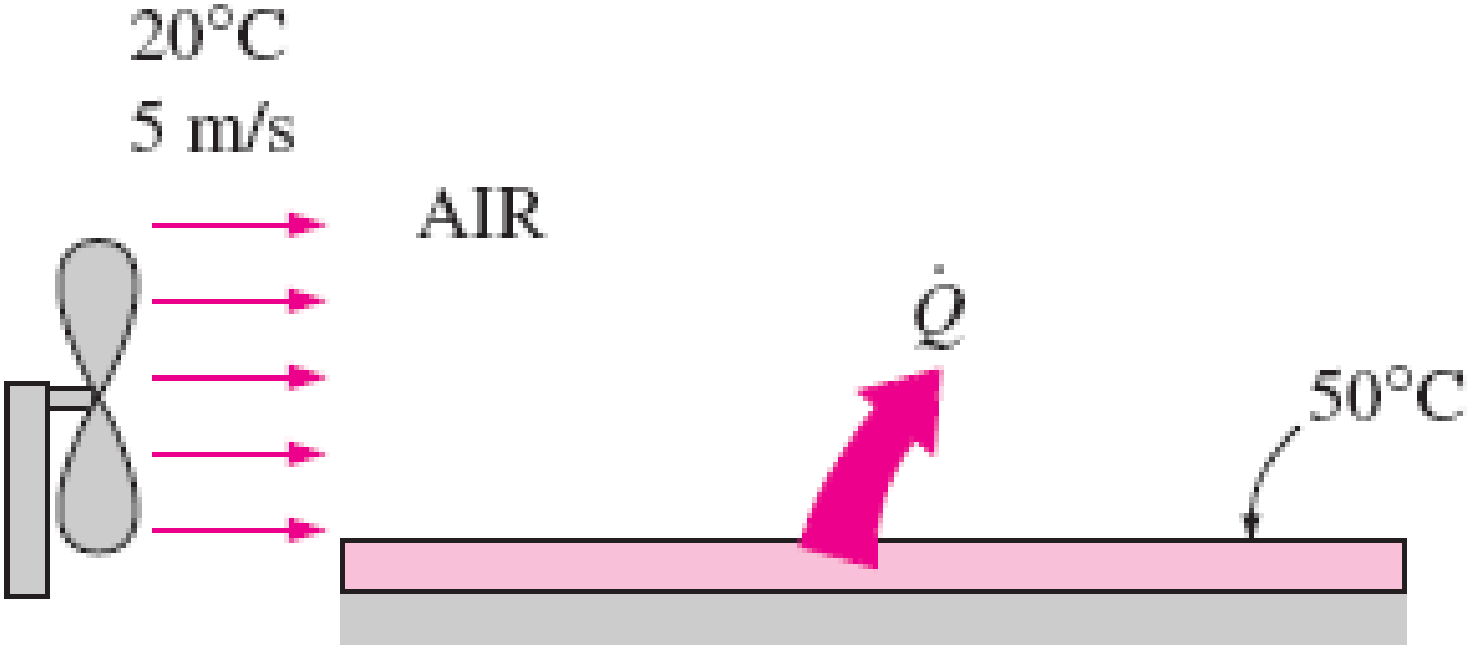
- As convection is dependent on the bulk movement of a fluid, it can only occur in liquids, gases and multiphase mixtures.
- Convective heat transfer is split into two categories: natural (or free) convection and forced (or advective) convection, also known as heat advection

Forced and Natural Convection



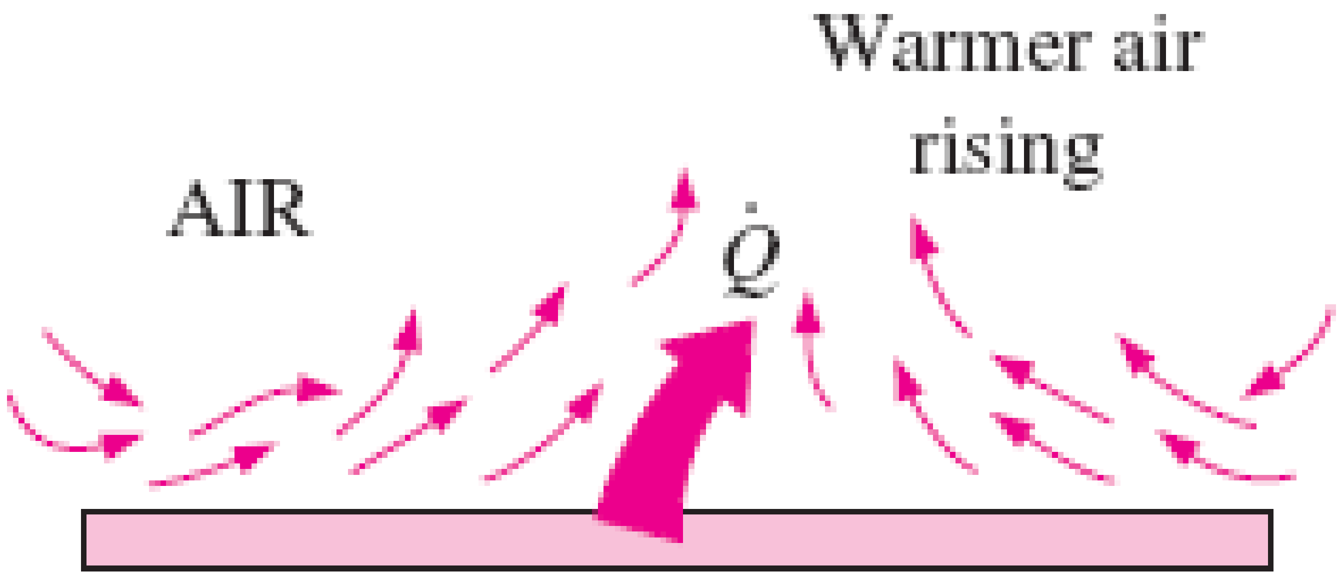
The cooling of a boiled egg by forced convection and natural convection

Forced Convection



(*a*) Forced convection

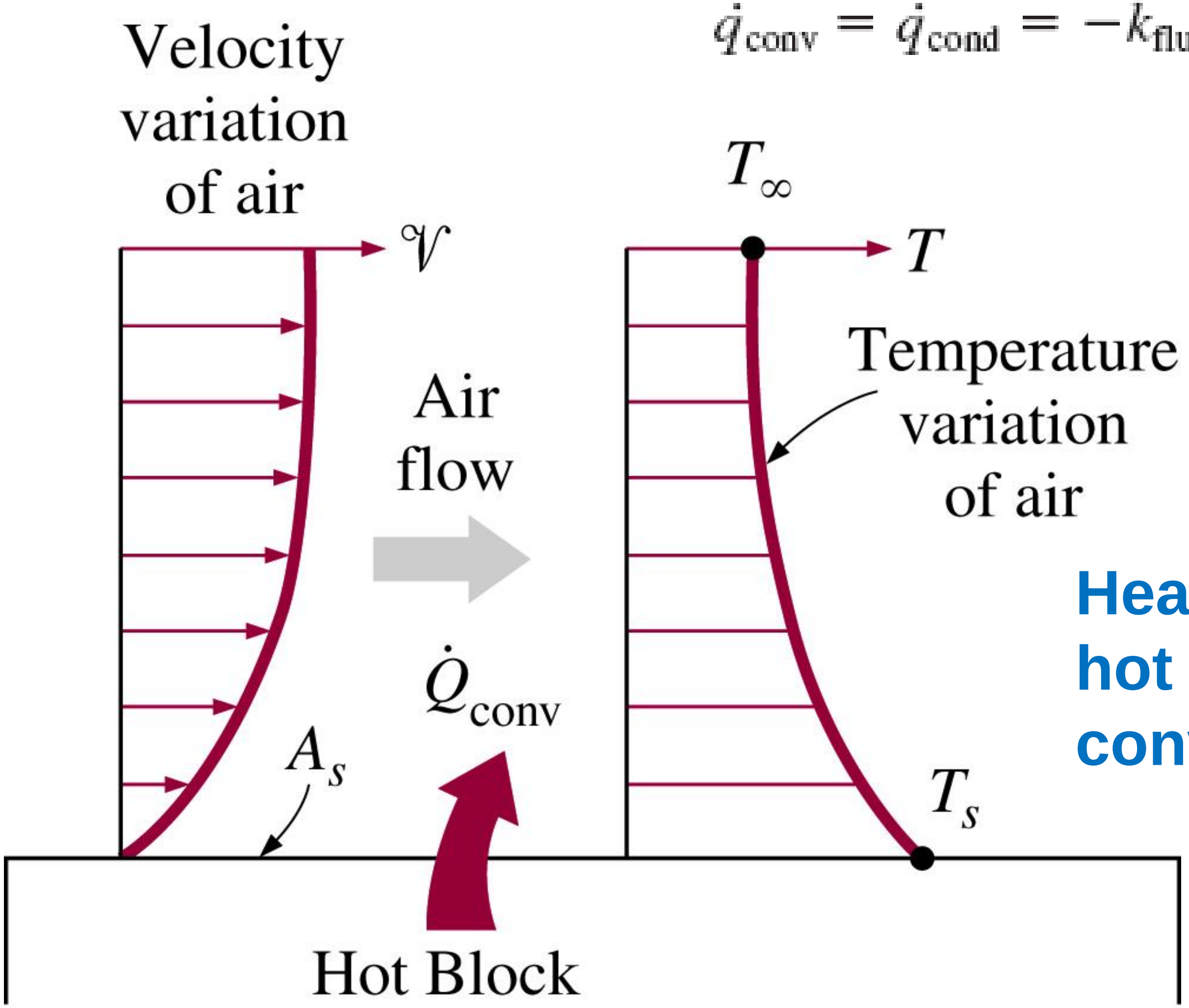
Free/Natural Convection



(*b*) Free convection

CONVECTION

$$\dot{q}_{conv} = \dot{q}_{cond} = -k_{fluid} \left.\frac{\partial T}{\partial y}\right|_{y=0} \qquad (W/m^2)$$



Heat transfer from a hot surface to air by convection

Natural Convection

- Natural convection is a mechanism, or type of heat transport in which the fluid motion is not generated by any external source (like a pump, fan, suction device, etc.) but only by density differences in the fluid occurring due to temperature gradients.

- The driving force for natural convection is buoyancy, a result of differences in fluid density. Because of this, the presence of gravity or an equivalent force (arising from the equivalence principle, such as acceleration, centrifugal force or Coriolis force) is essential for natural convection.

- Natural convection has attracted a great deal of attention from researchers because of its presence both in nature, seen in the rising plume of hot air from fire, oceanic currents, and sea-wind formation, and in engineering applications such as formation of microstructures during the cooling of molten metals and in shrouded fins and solar ponds.

- A very common industrial application of natural convection is air cooling: this can happen on small scales (computer chips) to large scale process equipment.

- Mathematically, the tendency of a particular system towards natural convection relies on the Grashof number (Gr), which is a ratio of buoyancy force and viscous force.
- The parameter β is the coefficient of thermal expansion, g is acceleration due to gravity, ΔT is the temperature difference between the hot surface and the bulk fluid (K), L is the characteristic length (this depends on the object) and ν is the viscosity.
- For liquids, values of β are tabulated. For an ideal gas, this number may be simply found:
  - $PV = nRT$
- Thus, the Grashof number can be thought of as the ratio of the upwards buoyancy of the heated fluid to the internal friction slowing it down. In very sticky, viscous fluids, fluid movement is restricted, along with natural convection. In the extreme case of infinite viscosity, the fluid could not move and all heat transfer would be through conductive heat transfer

The relative magnitudes of the Grashof and Reynolds number determine which form of convection dominates, if forced convection may be neglected, whereas if natural convection may be neglected. If the ratio is approximately one both forced and natural convection need to be taken into account

- Natural convection is highly dependent on the geometry of the hot surface, various correlations exist in order to determine the heat transfer coefficent. The Rayleigh number (Ra) is frequently used, where:

- Ra = GrPr where Pr is the Prandtl number

Geometry	Characteristic Length	Nu_0
Inclined Plane	x (Distance along plane)	0.68
Inclined Disk	9D/11 (D = Diameter)	0.56
Vertical Cylinder	x (height of cylinder)	0.68
Cone	4x/5 (x = distance along sloping surface)	0.54
Horizontal Cylinder	$\pi D / 2$ (D = Diameter of cylinder)	0.36π

Forced Convection

- Forced convection is a mechanism, or type of heat transport in which fluid motion is generated by an external source (like a pump, fan, suction device, etc.). Forced convection is often encountered by engineers designing or analyzing heat exchangers, pipe flow, and flow over a plate at a different temperature than the stream (the case of a shuttle wing during re-entry, for example).
- However, in any forced convection situation, some amount of natural convection is always present. When the natural convection is not negligible, such flows are typically referred to as **mixed convection**.

- When analysing potentially mixed convection, a parameter called the Archimedes number (Ar) parametizes the relative strength of free and forced convection.

$$\mathbf{Ar = Gr/Re^2}$$

- The Archimedes number represents the ratio of buoyancy force and inertia force, and which stands in for the contribution of natural convection.
- When Ar >> 1, natural convection dominates and when Ar << 1, forced convection dominates.

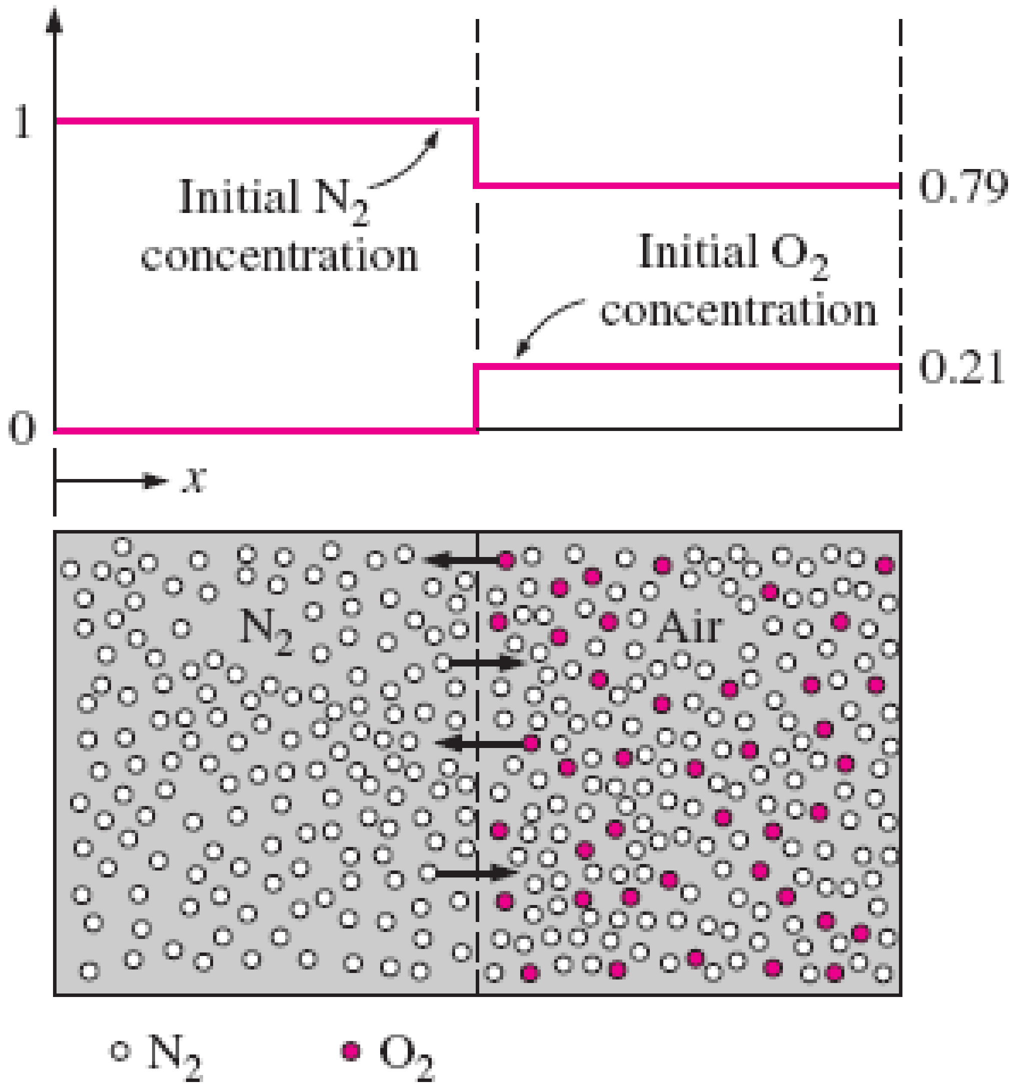
- When natural convection isn't a significant factor, mathematical analysis with forced convection theories typically yields accurate results. The parameter of importance in forced convection is the Peclet number, which is the ratio of advection (movement by currents) and diffusion (movement from high to low concentrations) of heat.

- When the Peclet number is much greater than unity (1), advection dominates diffusion. Similarly, much smaller ratios indicate a higher rate of diffusion relative to advection.

Diffusion

- **Diffusion** is the movement of particles from an area of high concentration to an area of low concentration in a given volume of fluid (either liquid or gas) down the concentration gradient.

- For example, diffusing molecules will move randomly between areas of high and low concentration but because there are more molecules in the high concentration region, more molecules will leave the high concentration region than the low concentration one.



$$\dot{Q} = -k_{\text{diff}} A \frac{dC}{dx}$$

Newton's Law of Cooling

- *A related principle, **Newton's law of cooling**, states that the rate of heat loss of a body is proportional to the difference in temperatures between the body and its surroundings, or environment.*

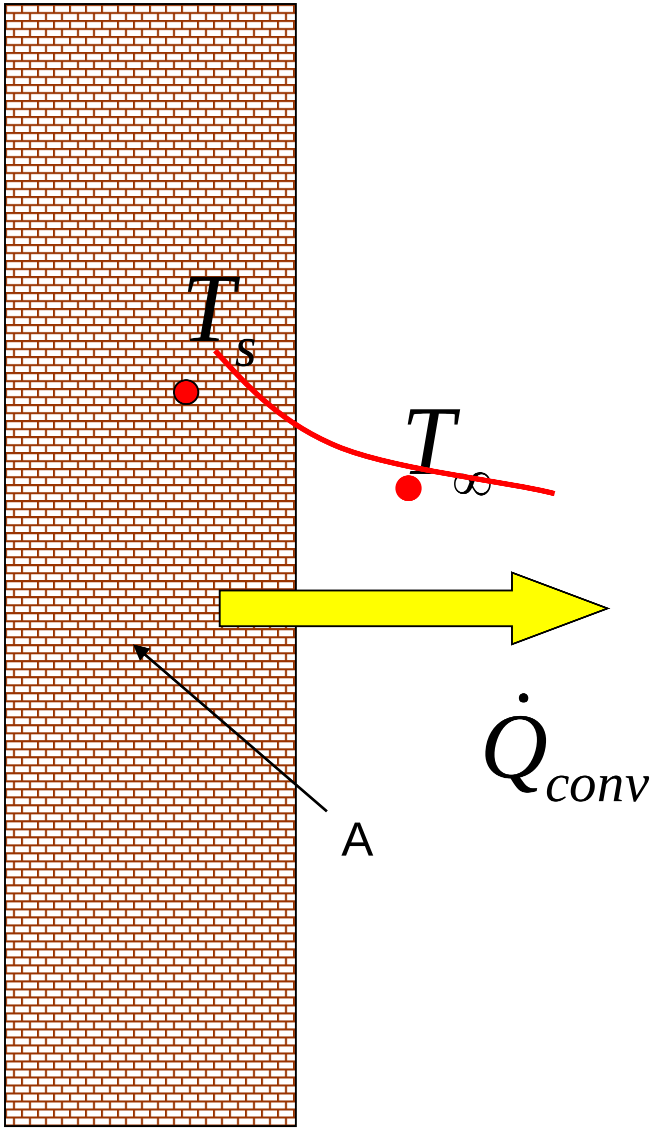
- *The law is* $Q = h.A.(T_o - T_\infty)$
  - Q = Thermal energy transfer in joules
  - h = Heat transfer coefficient
  - A = Surface area of the heat being transferred
  - T_o = Temperature of the object's surface
  - T_∞ = Temperature of the environment

Newton's law of cooling

$$\dot{Q}_{conv} = hA(T_s - T_\infty)$$

$$h \qquad [W/m^2K]$$

Convection heat transfer coefficient:



The End

Terima kasih

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