# TKU211122
# Fluid, Heat & Waves
# Homework #2 : Thermodynamics

Dzuhri Radityo Utomo

Department of Electrical and Information Engineering
Universitas Gadjah Mada

November 24, 2021

I. Problem #1 : Gas Expansion

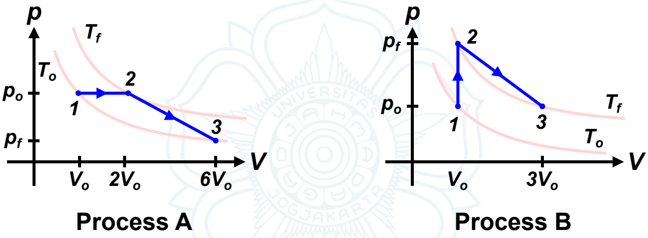
II. Peoblem #2 : Thermal Equilibrium

III. Problem #3 : Maxwell-Boltzmann Distribution

# Homework #2

- Ini adalah Homework #2 dengan materi mengenai Termodinamika.
- Pengerjaan tugas ini **tidak boleh** diketik dengan komputer (harus menggunakan tulisan tangan), dan pengumpulan tugas ini akan dilakukan melalui *Google Classrom*. Pastikan bahwa tulisan pada pekerjaan anda **dapat terbaca dengan jelas** pada hasil *scan* atau foto yang anda unggah.
- Konversikan hasil *scan* atau foto pekerjaan anda menjadi *file* *.pdf.
- Berilah nama *file* adalah "FFKG_(Kelas A/B)_HW2_(6-digit NIU Anda)_(Inisial Nama Anda)". Sebagai contoh "FFKG_A_HW2_456789_DRU.pdf".
- Tetap Sehat dan Selamat Mengerjakan!

# Problem #1 : Gas Expansion

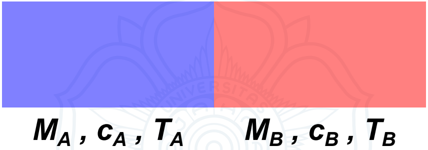



An ideal gas (with number of moles $n$ and molar specific heat $C_v$) inside a sealed container is expanded following two different processes shown in the figure above.

- (A) Determine the value of $P_f$ and $T_f$ in these processes!
- (B) Determine the amount of heat $Q$ added into the system during these processes!

Express your answer only in terms of $n$, $C_v$, $T_o$, $V_o$ and universal gas constant $R$!

# Problem #2 : Thermal Equilibrium




A metal block with mass $M_A$ and initial temperature $T_A$ touches another metal block with mass $M_B$ and initial temperature $T_B$. Suppose that the specific heat of the two metals are $c_A$ and $c_B$, respectively.

- (A) Determine the final temperature $T_f$ of the two metal blocks!
- (B) Determine the change in blocks' temperature $\Delta T_A = T_f - T_A$ and $\Delta T_B = T_f - T_B$!
- (C) Let us assume that $M_A = M_B$. In this condition, it is known that $|\Delta T_A| > |\Delta T_B|$. Which material/metal block has higher specific heat?

# Problem #3 : Maxwell-Boltzmann Distribution

Inside a sealed container with temperature $T$, there exists $N_o$ atoms/molecules of gas with mass $m$. The speed distribution of the gas atoms/molecules follows a function described as follows

$$N_v(v) = 4\pi N_o \left( \frac{m}{2\pi k_B T} \right)^{3/2} v^2 e^{-mv^2/2k_B T} \tag{1}$$

which is called as a Maxwell-Boltzmann Distribution. This distribution describes that the number of atoms/molecules that have speed between $v$ and $v + dv$ is given by

$$dN = N_v(v)dv$$

so that when we want to determine the total atoms/molecules that have speed between $v_1$ and $v_2$, we need to perform the following integral operation

$$N = \int_{v_1}^{v_2} N_v(v)dv$$

# Problem #3 : Maxwell-Boltzmann Distribution

Making use the information from the Maxwell-Boltzmann Distribution, prove the following statements!

- A Root-mean-square (RMS) speed of the gas atoms/molecules is given by

$$v_{rms} = \sqrt{\frac{3k_B T}{m}} \tag{2}$$

- B Average speed of the gas atoms/molecules is given by

$$v_{avg} = \sqrt{\frac{8k_B T}{\pi m}} \tag{3}$$

- C Most probable speed of the gas atoms/molecules is given by

$$v_{mp} = \sqrt{\frac{2k_B T}{m}} \tag{4}$$

# Problem #3 : Maxwell-Boltzmann Distribution

**Hint :**

$$\int_0^\infty x^3 e^{-ax^2} = \frac{1}{2a^2}$$

$$\int_0^\infty x^4 e^{-ax^2} = \frac{3}{8}\sqrt{\frac{\pi}{a^5}}$$