

Física Estadística I

Tarea 01: Termodinámica Clásica

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Nombre del Estudiante: _____

Problema 1 *Diesel engine*

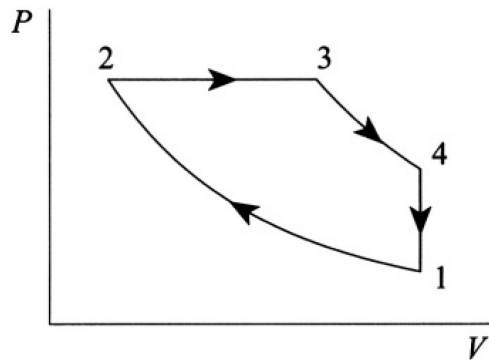
For an ideal Diesel cycle (see figure),

- (a) Demonstrate that the internal energy is a conserved quantity, that is, $\Delta U_{tot} = 0$.
- (b) Show that the thermal efficiency of this cycle is given by,

$$\eta = 1 - \frac{1}{\gamma} \frac{(1/r_E)^\gamma - (1/r_c)^\gamma}{(1/r_E) - (1/r_c)},$$

where the ratio $r_c = V_1/V_2$ is called the *compression ratio* and the ratio $r_E = V_1/V_3$ is called the *expansion ratio* for a diesel engine.

- (c) Take $r_c = 20$, $r_E = 5$, and $\gamma = 1.4$ and calculate the thermal efficiency.



Hints:

- 1. The processes $1 \rightarrow 2$ and $3 \rightarrow 4$ are adiabatic.
- 2. For an adiabatic process it holds $T/T_0 = (V_0/V)^{\gamma-1}$, where $\gamma = C_p/C_v$.
- 3. For ideal gases, $\gamma = 5/3$ and $C_p - C_v = Nk$.

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Problema 2 *Helmholtz free energy*

A substance has the following properties,

- (i) At a constant temperature T_0 the work done by it on expansion from V_0 to V is,

$$W = -KT_0 \ln \left(\frac{V}{V_0} \right).$$

- (ii) The entropy is given by,

$$S = k \frac{V}{V_0} \left(\frac{T}{T_0} \right)^a,$$

where V_0 , T_0 , and a are fixed constants.

- (a) Show that the Helmholtz free energy is the following:

$$F(T, V) = -kT_0 \ln \left(\frac{V}{V_0} \right) + k \left(\frac{V}{V_0} \right) \frac{T_0}{a+1} \left[1 - \left(\frac{T}{T_0} \right)^{a+1} \right].$$

- (b) Find the following equation of state:

$$pV = kT_0 \left[1 - \frac{V}{(a+1)V_0} \left\{ 1 - \left(\frac{T}{T_0} \right)^{a+1} \right\} \right].$$

- (c) Find that the work done at an arbitrary constant temperature T , from point 1 to point 2 is given by:

$$W = -kT_0 \ln \left(\frac{V_2}{V_1} \right) + \frac{kT_0}{(a+1)V_0} \left[1 - \left(\frac{T}{T_0} \right)^{a+1} \right] (V_2 - V_1).$$

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