

$T_1 = 291^\circ\text{K}$ $T_2 = 305^\circ\text{K}$
 $V_1 = 21 \times 10^3 \text{ cm}^3$ and $V_2 = 12.7 \times 10^3 \text{ cm}^3$

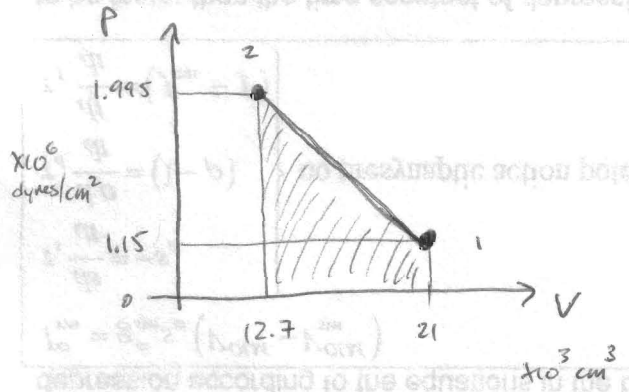
Since the gas is ideal, we can use $PV = NkT$ to get the pressures.

$$P = Nk \left(\frac{T}{V} \right) \quad P_1 = (6.02 \times 10^{23}) \left(1.38 \times 10^{-16} \frac{\text{erg}}{\text{K}} \right) \left(\frac{291^\circ\text{K}}{21 \times 10^3 \text{ cm}^3} \right)$$

$$P_1 = 1.15 \times 10^6 \text{ dynes/cm}^2$$

$$P_2 = N_A k \left(\frac{305^\circ\text{K}}{12.7 \times 10^3 \text{ cm}^3} \right) = 1.995 \times 10^6 \text{ dynes/cm}^2$$

So the PV diagram looks like this; were told that the process is a straight line.



The work performed is $W = - \int P dV$
 $W = \int_1^2 P dV = \text{area in the figure}$

So, $W = \text{rectangle} + \text{triangle}$

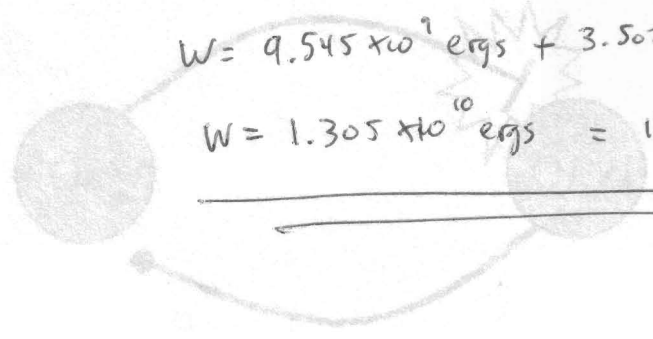
$$W = (21 - 12.7)(10^3 \text{ cm}^3) (1.15 \times 10^6 \text{ dynes/cm}^2) + \frac{1}{2} (21 - 12.7)(10^3 \text{ cm}^3) (1.995 - 1.15)(10^6 \text{ dynes/cm}^2)$$

$$W = 9.545 \times 10^7 \text{ ergs} + 3.507 \times 10^7 \text{ ergs}$$

$$W = 1.305 \times 10^{10} \text{ ergs} = 1305 \text{ Joules}$$

This is positive, so this

is work done on the gas.



to find the heat, use the 1st law: $du = \delta w + \delta Q$

so $\Delta Q = \Delta u - \Delta w$ where Δw is what we get above.

Δu is obtained from $c_v = \frac{du}{dT}$, which we know is independent of volume.

$$\text{so } \Delta u = \int du = \int c_v dT = c_v \int dT = \frac{5}{2} Nk \int_{T_1}^{T_2} dT = \frac{5}{2} Nk (305 - 291) K$$

$$\Delta u = 2.91 \times 10^9 \text{ ergs} = 291 \text{ Joules.}$$

$$\text{so } \Delta Q = 291 \text{ Joules} - 1305 \text{ Joules} = -1014 \text{ Joules.}$$

Since this is negative, this heat is delivered to the surroundings.

2. a)

an adiabatic process has $\delta q = 0$.

So, the 1st law reads (for $N = \text{const}$)

$$du = \delta q + \delta w = \delta w$$

$$du = -pdv.$$

• for an ideal gas, $u = \frac{3}{2} NkT$ and $c_v = \frac{\partial u}{\partial T} = \frac{3}{2} Nk$

so

$$du = c_v dT = -pdv$$

$$\frac{3}{2} Nk dT = -pdv$$

• From the ideal gas law, $PV = NkT$, so $p = \frac{NkT}{V}$

and

$$\frac{3}{2} Nk dT = -NkT \frac{dv}{v}$$

$$\frac{3}{2} \frac{dT}{T} = -\frac{dv}{v}$$

$$\frac{3}{2} \ln\left(\frac{T}{T_0}\right) = -\ln\left(\frac{v}{v_0}\right)$$

$$\left(\frac{T}{T_0}\right)^{3/2} = \frac{v_0}{v}$$

• from ideal gas law, $V = \frac{NkT}{P}$, so

$$\frac{NkT}{P} T^{3/2} = \text{const}$$

$$\frac{T^{5/2}}{P} = \text{const}$$

or $\frac{T}{P^{2/5}} = \text{const}$

model so that deformation does not involve allowing for localized
 fluctuations. As discussed in section (proposed lecture) we intend to include deformation
 in this model, there is no need to consider for coupling out of the principal block, since there is no

the excitation block

(a) the excitation population remains at an elevated level through the rate is reduced as
 excitation population is more excited due to lack of inhibition (b) there is only excitation (c) and inhibition
 there is no DB, the time decreases (d) there is only inhibition DB (of a) as in the experiment, the
 time scales. A linear plot showing n as a function of time for a solution starting with an initial value where n

EVOLUTION HERE! I will need now, so I will send the equations to follow as I (probably) find time to do

best practice

Here the two functions are the spatially invariant coupling functions within and between the two
 Heisenberg function $\psi(x) = 0$ for $x < 0$ and $\psi(x) = 1$ for $x > 0$ (I would consider this for you, but it would
 and dimensionless model (based on bases of $\psi(x)$) with an added deformation block term within the
 We have developed the following third rate model for the deformation block. It is a modification of the first

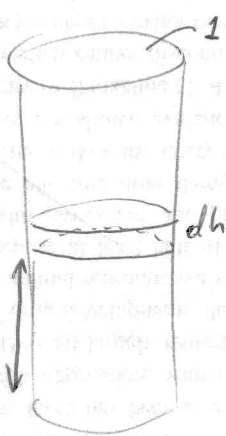
more detailed model

model it shows for the stable discovery of waves and associated patterns that may have been missed in a
 common or linear. Recent works of Fazio and dimensionless and classical and collective have been seen a
 detailed periodic dynamics. A third rate continuum model is a good choice, such as in the style of Wilson and
 others. A specific mechanism in the dynamics in the case of a two level system in which one is interested in
 which are more computationally and analytically tractable. Simplified models are very helpful for isolating the
 essential physics. Thus the model is already an approximation. It is helpful to look at simplified models
 detailed properties; models are important. However, in many cases the detailed parameters cannot be

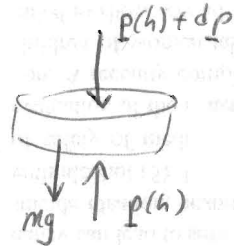
[this] shows explicit Continuum models - the evolution of a pump

Continuum models

2. b) consider a column of air of cross-section = 1 unit area.



more specifically, consider a slab of air as shown, located at height h and of thickness dh . Forces are as shown



The force on the lower face is $1 \times p(h)$.

The force on the upper face is $p(h) + dp$. mg is the force of gravity.

Balancing forces,

$$p(h) - [p(h) + dp] - mg = 0$$

$$dp = -mg$$

in terms of the density of the air, and the volume of the slab, this is

$$dp = -\rho(1) dh g.$$

The density can be expressed via the ideal gas law, $PV = NkT$, as

$$\rho = \frac{MN}{V} = \frac{MNP}{NkT} = \frac{MP}{kT}$$

where M is the average mass of a particle of air.

$$\text{So } dp = -\frac{Mg}{kT} p dh$$

$$\text{or } \frac{dp}{p} = -\frac{Mg}{kT} dh = d(\ln p).$$

Recall from part (a) that $\frac{T}{P^{2/5}} = \text{const}$, so $T = c P^{2/5}$.

That's $\ln T = \ln c + \frac{2}{5} \ln P$

and $\frac{dT}{T} = \frac{2}{5} \frac{dP}{P} \Rightarrow \frac{dP}{P} = \frac{5}{2} \frac{dT}{T}$

plug this in above.

$$\frac{dP}{P} = \frac{5}{2} \frac{dT}{T} = - \frac{Mg}{kT} dh$$

$$\frac{dT}{dh} = - \frac{2}{5} \frac{Mg}{k}$$

given: 1 mole of particles of air = $N_a = 280.88 \text{ g}$

$$M = \frac{280.88}{N_a} \text{ grams}$$

So

$$- \frac{2}{5} \left(\frac{280.88 \text{ (grams)}}{N_a} \right) \left(\frac{9.8 \text{ m}}{\text{s}^2} \right) \left(\frac{\text{ok}}{1.38 \times 10^{-16} \text{ ergs}} \right) \left(\frac{\text{erg}}{\text{dyne cm}} \right) \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)$$

$$\cdot \left(\frac{\text{dyne s}^2}{\text{gram cm}} \right) \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)$$

$$= -1.36 \times 10^{-2} \frac{\text{ok}}{\text{m}} \cdot \left(\frac{1000 \text{ m}}{1 \text{ km}} \right) = -13.6 \frac{\text{ok}}{\text{km}}$$

Note: The assumption that air is monoatomic is not good, since it's mostly Nitrogen gas (N_2) and oxygen (O_2).

Because a diatomic gas has extra degrees of freedom,

The result quoted in part (a) should be replaced with

$$T = C p^{2/7} \quad \text{This results in an answer to part (b)}$$

$$v \approx -9.8 \text{ km/km}$$

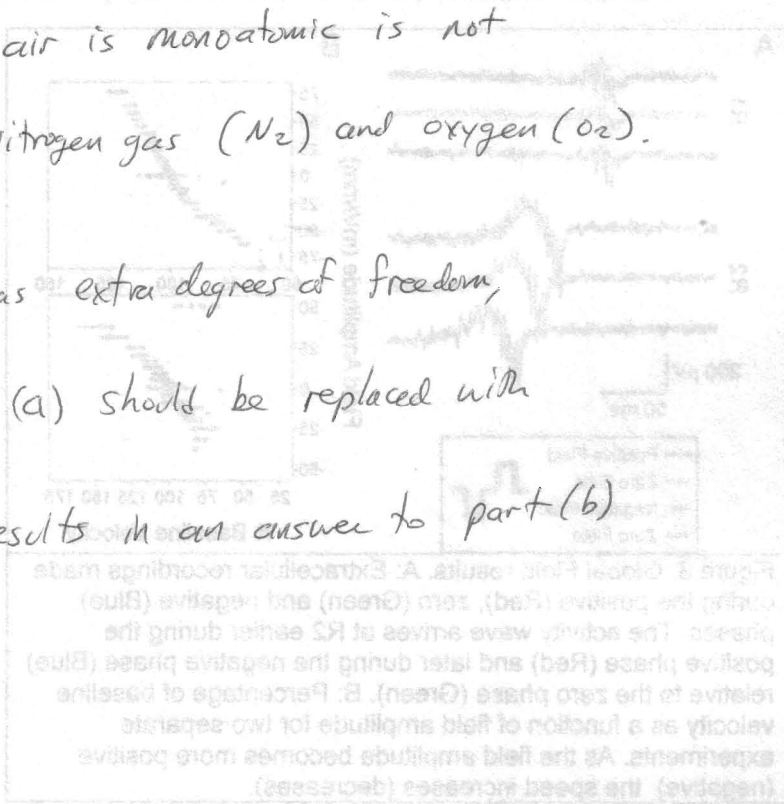


Figure 3. Extracellular recordings made during the positive (red) and negative (blue) phases. The activity wave amplitudes at R2 either during the positive phase (red) and later during the negative phase (blue) relative to the zero phase (green). B: Percentage of baseline velocity as a function of field amplitude for two separate experiments. As the field amplitude becomes more positive (negative), the speed increases (decreases).

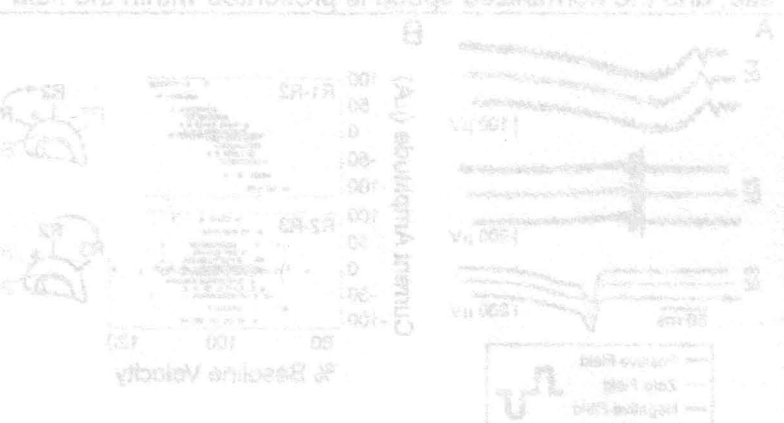


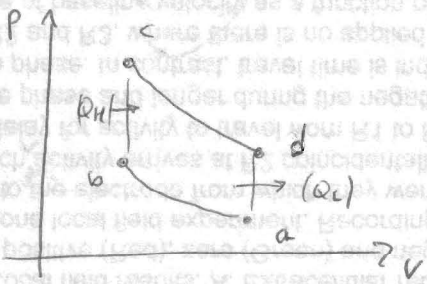
Figure 4. Local field results. A: Extracellular recordings made during the positive (red) and negative (blue) phases during the local field experiment. Recordings are grouped according to the electrode from which they were recorded and aligned such that activity amplitudes at R2 coincidentally for all phases. The time delay for activity to travel from R1 to R2 is shorter during the positive phase and longer during the negative phase, relative to the zero phase. In contrast, travel time is independent of phase between R2 and R3, where there is no applied field. The field is applied between R1 and R2. Modulation of propagation speed with applied field is seen only between the electrodes that span the field (R1-R2). Outside the field, there is no effect (R2-R3).

The speed of propagation as a function of field is shown in Figure X.B. The field was applied near the initiation site, and the normalized speed is presented within the field (red/green, middle trace). The speed of propagation is shorter during the application of a positive field (red/green, middle trace) and is longer during the application of a negative field (blue, lower trace), relative to zero. The effect of the locally applied electric field is shown in the extracellular recordings from one experiment (Figure 4A). The field was applied locally to the region spanned by R1 and R2 (see Figure 1B). To best observe the changes in propagation speed, we plot the raw extracellular signals aligned such that waves from R2 coincide in time. The time to travel between R2 and R3 is the same for all phases of applied field. However, the time to travel between the electrodes that span the field (R1-R2) is shorter during the application of a positive field (red/green, middle trace) and is longer during the application of a negative field (blue, lower trace), relative to zero. The speed of propagation is presented within the field (red/green, middle trace).

$$v = \frac{d}{t} = \frac{100 \mu m}{10 \mu s} = 10^7 \text{ km/km}$$

3. In the Otto cycle, heat is exchanged only during

the constant-volume processes bc and da; the other paths are adiabatic.



• let $|Q_H|$ be the amount of heat added in bc

• let $|Q_C|$ be the amount of heat ejected in da.

• Since this occurs at const. volume,

$$|Q_H| = C_V (T_c - T_b)$$

$$|Q_C| = C_V (T_d - T_a)$$

(where the subscripts on the T s identify the position on the PV diagram)

• So the efficiency is

$$\eta = 1 - \frac{|Q_C|}{|Q_H|} = 1 - \frac{(T_d - T_a)}{(T_c - T_b)}$$

• for an adiabatic process with an ideal gas, $PV^{5/3} = \text{const}$

or, since $P = \frac{NKT}{V}$,

$$\frac{NKT}{V} V^{5/3} = NKT V^{2/3} = \text{const}$$

i.e.

$$TV^{2/3} = \text{const}$$

• so, since cd and ab are adiabatic processes,

$$T_c V_c^{2/3} = T_d V_d^{2/3} \quad \text{and} \quad T_a V_a^{2/3} = T_b V_b^{2/3}$$

• write

$$T_d = T_c \left(\frac{V_c}{V_d} \right)^{2/3} \quad \text{and} \quad T_a = T_b \left(\frac{V_b}{V_a} \right)^{2/3}$$

• so,

$$\eta = 1 - \left(\frac{T_d - T_a}{T_c - T_b} \right) = 1 - \left(\frac{T_c \left(\frac{V_c}{V_d} \right)^{2/3} - T_b \left(\frac{V_b}{V_a} \right)^{2/3}}{T_c - T_b} \right)$$

• note that $V_c = V_b$ and $V_d = V_a$, so

$$\eta = 1 - \left(\frac{T_c \left(\frac{V_b}{V_a} \right)^{2/3} - T_b \left(\frac{V_b}{V_a} \right)^{2/3}}{T_c - T_b} \right)$$

$$\eta = 1 - \left(\frac{V_b}{V_a} \right)^{2/3}$$

i.e.

$$\eta = 1 - \left(\frac{V_a}{V_b} \right)^{-2/3}$$

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