Thu 21 Mar

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Computer project feedback

$$|X(N)|^\theta = |\sum_i x_i|^\theta \rightarrow \sum_i |x_i|^\theta$$

$$\eta = \frac{W_{out} - W_{in}}{Q_{in}} \qquad W = -\int P dV \qquad Q = \int T dS$$

$$W_{out} = -W_{34} = -\Delta\langle E\rangle_{34} = -\frac{3}{2}N(T_4 - T_3)$$

$$W_{in} = W_{12} = \frac{3}{2}N(T_2 - T_1)$$

$$Q_{in} = Q_{23} = \frac{3}{2}N(T_3 - T_2)$$

$$\eta = \frac{T_3 - T_4 - T_2 + T_1}{T_3 - T_2} = 1 - \frac{T_4(1 - T_1/T_4)}{T_3(1 - T_2/T_3)} = 1 - \frac{T_4}{T_3} = 1 - \frac{1}{r^{2/3}}$$

$$= 1 - \frac{T_1}{T_2}$$

Adiabatic $\rightarrow$ constant $VT^{3/2}$

$$V_1 T_1^{3/2} = V_2 T_2^{3/2}$$

$$r = \frac{V_1}{V_2} \qquad \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{2/3} = \frac{1}{r^{2/3}} = \frac{T_4}{T_3}$$

$$\frac{T_1}{T_4} = \frac{T_2}{T_3}$$

$$\eta = 1 - \frac{1}{r^{2/3}}$$

$$\eta = 1 - \frac{T_1}{T_2} < 1 - \frac{T_1}{T_3} = \eta_c \quad ✓$$

$$T_2 < T_3$$

$$\frac{1}{T_2} > \frac{1}{T_3}$$

Practical engines

Max η by increasing $r = \frac{V_1}{V_2}$

Realistic $\eta \sim 20\% - 30\%$

$\frac{V_1}{V_2}$ too large $\rightarrow$ auto-ignition ("knock")

Diesel's approach

Only compress air (no risk of spontaneous combustion)

then <u>inject</u> (diesel) fuel

η depends on both compression ratio $r = \frac{V_1}{V_2}$

and cutoff ratio $C = \frac{V_3}{V_2}$ $\qquad 1 < C < r$

Can have larger $r \rightarrow$ higher $\eta \sim 40\%$

Spin system

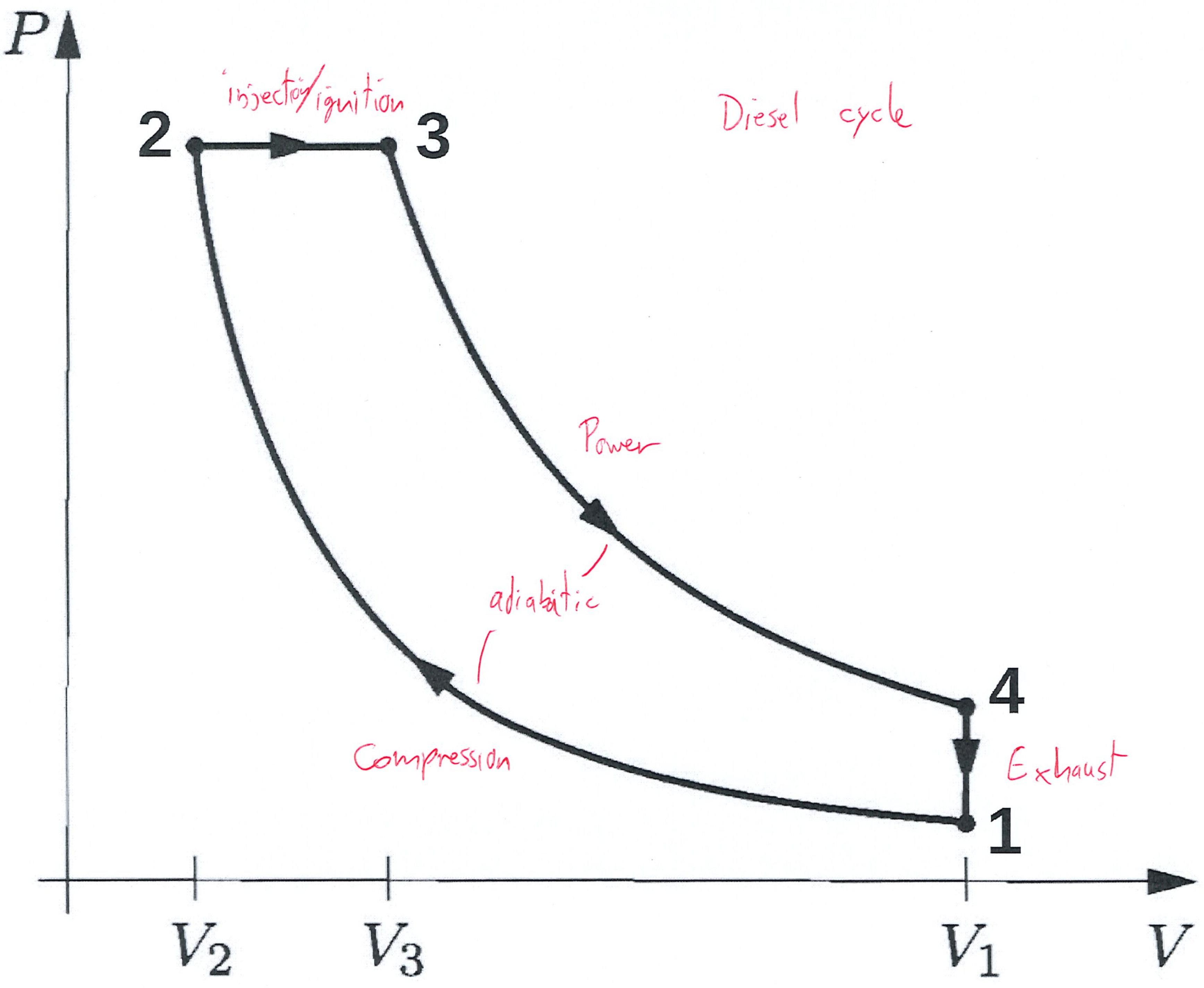
↑ ↓ ↑ $\Uparrow$ H
↓ ↑ ↑

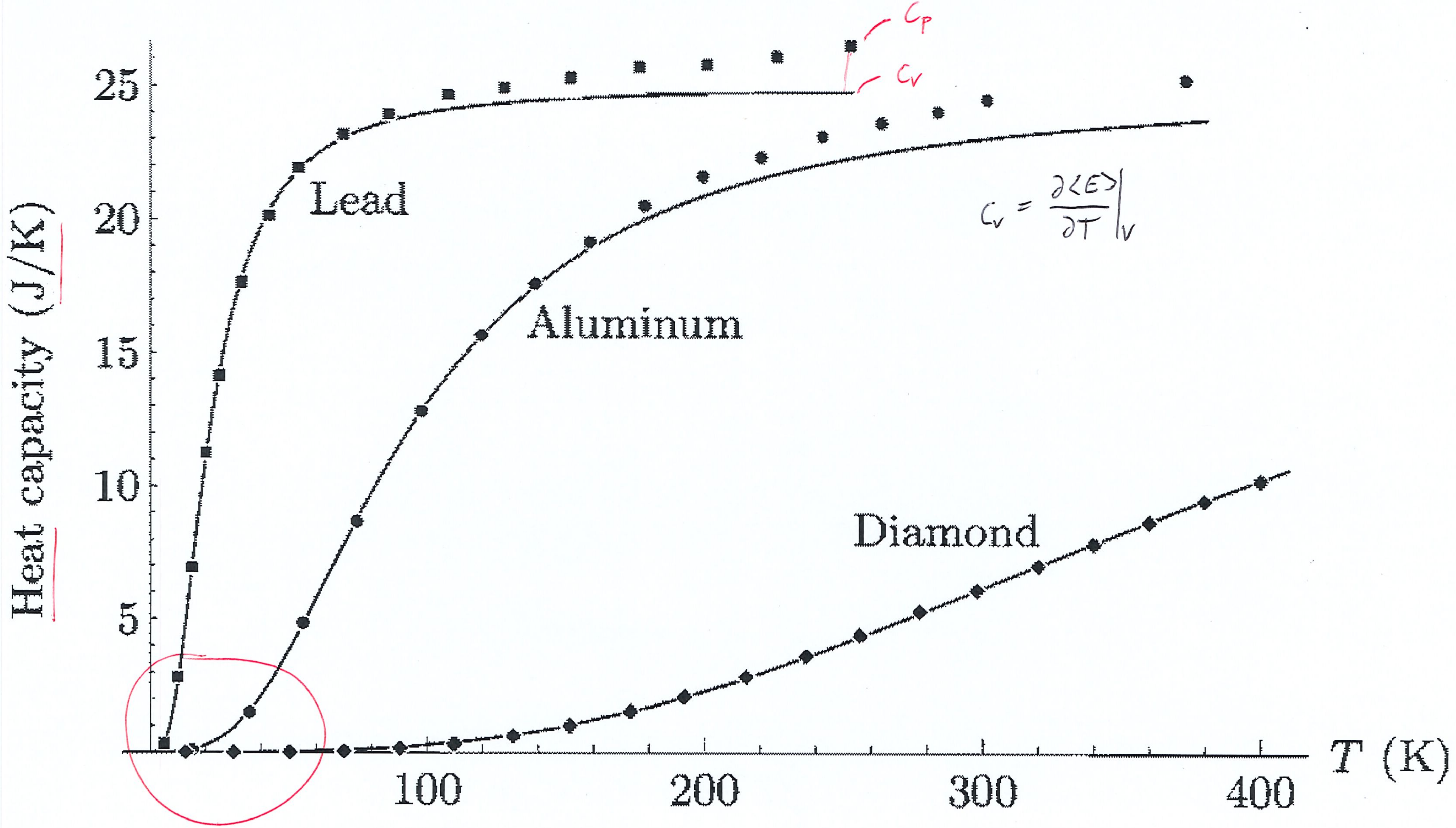
$$E = -NH \tanh(\beta H) \qquad \beta = 1/T$$

C_V approaches zero as $T \rightarrow 0$? ("third law")

C_V increases to constant for high T?

$\rightarrow$ Einstein solid


P
V
V_2
V_3
V_1
1
2
3
4
injection/ignition
Diesel cycle
Power
adiabatic
Compression
Exhaust



Heat capacity (J/K)
25
20
15
10
5
100
200
300
400
T (K)
Lead
Aluminum
Diamond
C_p
C_v
$C_v = \frac{\partial \langle E \rangle}{\partial T}\Big|_V$