Thermodynamics
Professor Anand T N C
Department of Mechanical Engineering
Indian Institute of Technology, Madras
Lecture - 29
Tutorial Problem - Part 3

(Refer Slide Time: 00:16)

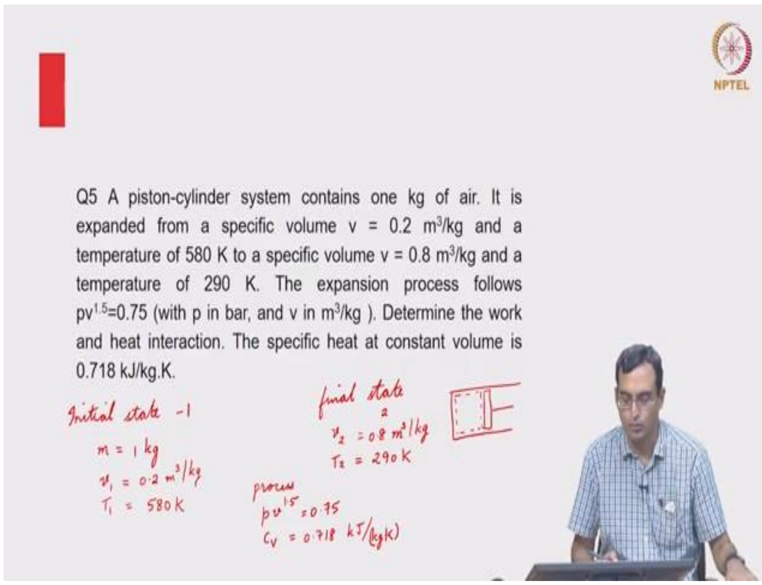
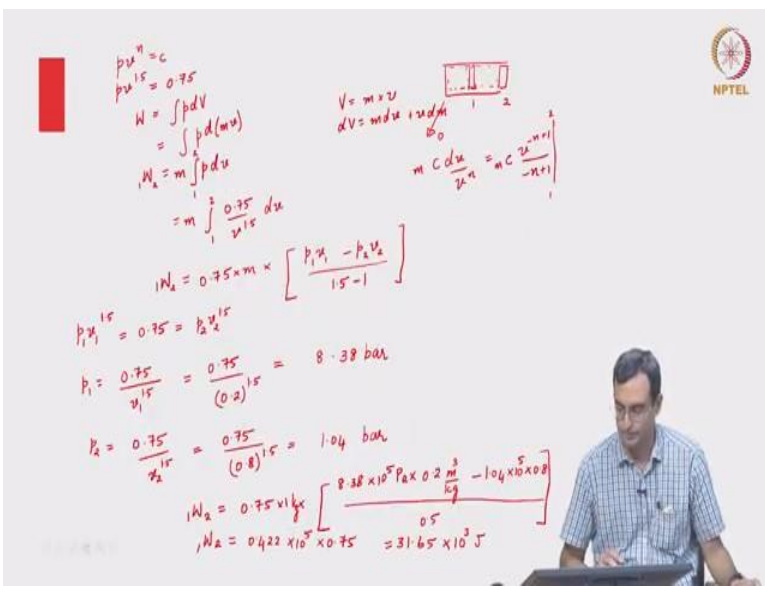


Figure 1.



Solution of the problem given in Fig. 1:

Initial state:

$$m = 1\ kg, v_1 = 0.2\frac{m^3}{kg}, T_1 = 580\ K$$

Final state:

$$v_2 = 0.8\frac{m^3}{kg}, T_2 = 290\ K$$

It is also given that $pv^{1.5} = 0.75$ and C_v is 0.718 kJ/kg·K.

The system is undergoing a polytropic process. Assuming the system to be a simple compressible system, the work done by the system is,

$W = \int pdV = \int pd(mv) = m \int pdv = m\int \frac{0.75}{v^{1.5}}dv$ [$d(mv) = vdm + mdv$, m is constant, i.e., dm=0, hence, $d(mv) = mdv$]

We have integrated this before.

$W = 0.75m\left(\frac{p_1v_1-p_2v_2}{1.5-1}\right)$ ....(1)

We need p_1 and p_2.

$$p_1v_1^{1.5} = 0.75 = p_2v_2^{1.5}$$

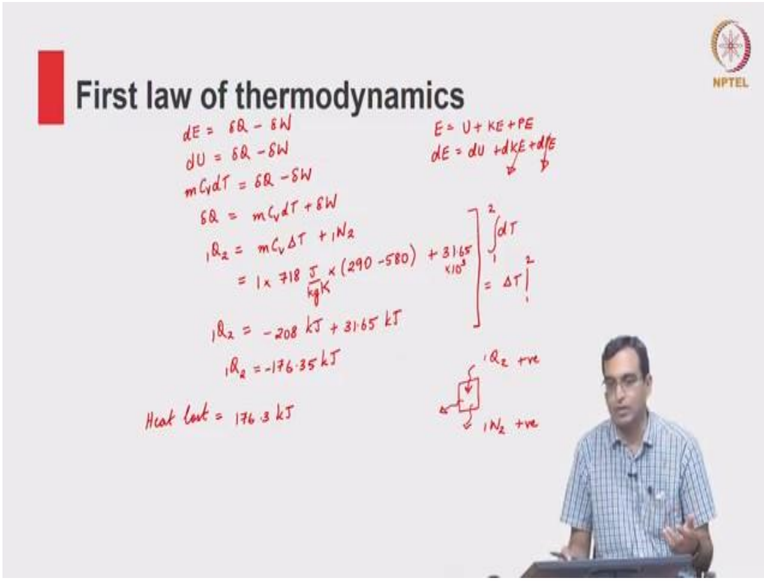
Hence, $p_1 = \frac{0.75}{v_1^{1.5}} = 8.38\ bar.$

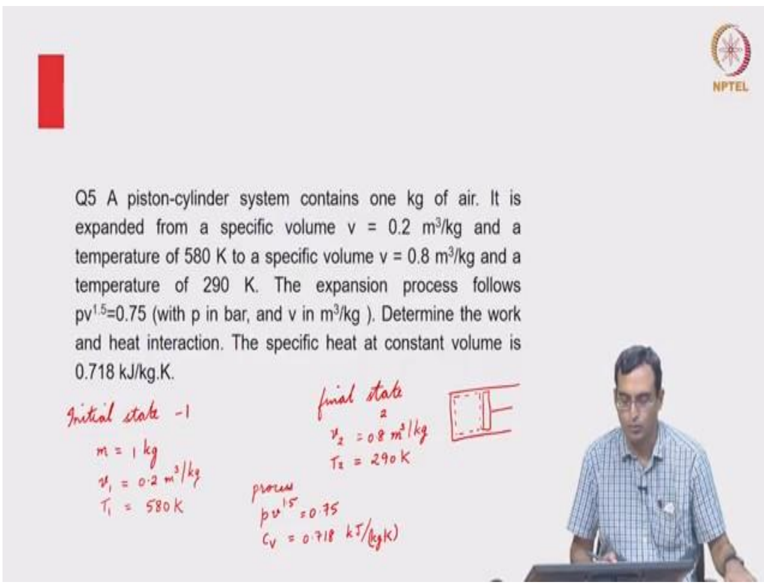
Similarly, $p_2 = 1.04\ bar.$

Substituting the values of p_1, p_2 and m in (1) and using SI units for all the quantities,

$$W = 31.65 \times 10^3\ J$$

(Refer Slide Time: 13:22)





We are also asked to calculate the heat interaction.

The first law of thermodynamics for the given system is,

$dU = \delta Q - \delta W$ (There are no changes in kinetic and potential energy. Hence, dE can be replaced by dU)

Hence, $mC_v dT = \delta Q - \delta W \rightarrow \delta Q = mC_v dT + \delta W$

Integrating,

$$Q = mC_v\Delta T + W = 1 \times 718 \times (290 - 580) + 31.65 \times 10^3 = -176.35\ kJ$$

The heat interaction is negative for the system. Hence, the system is losing heat.

The work interaction is positive for the system. Hence, the system is doing work.

Here, the system is losing energy by giving out heat and doing work.