Work critical: need work to run an A/C, fridge
need heat to run an engine to do work

§ 4.1,2 Definition, units

Work done by a force F_x acting on a point moving from a position 1 to a position 2 in the x-direction:

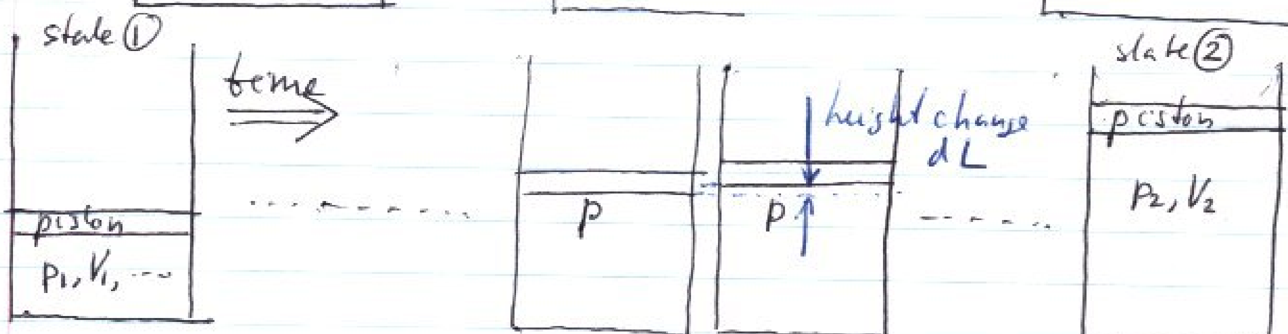
$$_1W_2 = \int_1^2 F_x \, dx \qquad \text{unit: N m} \equiv \text{Joule} = \text{J} \quad \text{or kJ}$$

Power = work/unit time unit: $\frac{J}{s} \equiv \text{Watt} = W$ or kW

1 hp [UK] = 550 ft lbf/s (in A.1)

Specific work $\boxed{w = \frac{W}{m}}$

§ 4.3 Work done at the moving boundary of a simple system



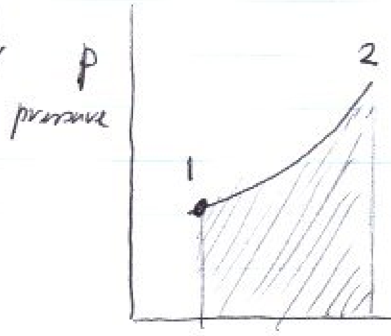
work done in this time interval $\delta W = F\,dL = pA\,dL = p\,dV$

Total work from state 1 to state 2:

$$\boxed{_1W_2 = \int_1^2 p\,dV} \quad \text{(ignoring viscous friction effects)}$$

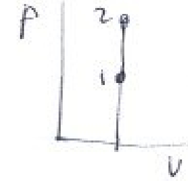
V3

Graphically

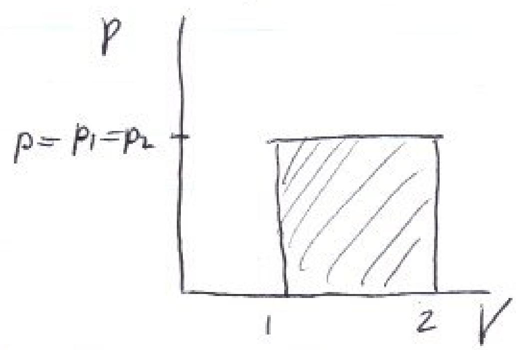


$_1W_2$ is shaded area

Easiest: isochoric: $\boxed{{}_1W_2 = 0 \text{ if } V = \text{constant}}$

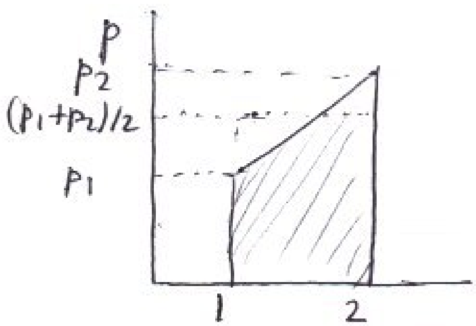


2nd Easiest: p = constant from 1 to 2



$$\boxed{\begin{array}{l} {}_1W_2 = p(V_2 - V_1) \\ \text{if } p = \text{constant} \end{array}}$$

Simple: p is a linear function of V (hence V is a linear function of p):



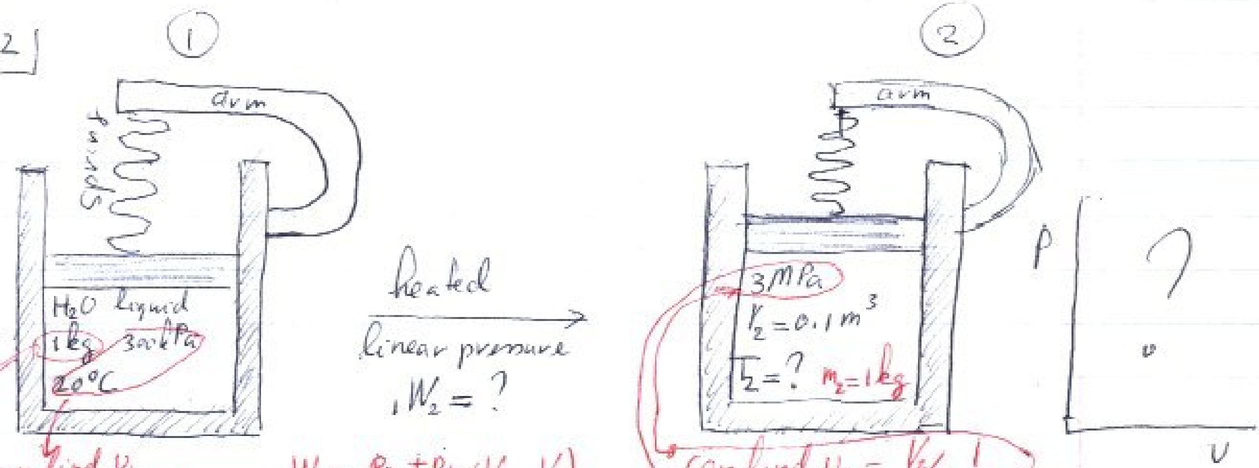
$$\boxed{\begin{array}{l} {}_1W_2 = \dfrac{p_1 + p_2}{2}(V_2 - V_1) \\ \text{if } p \text{ linear function of } V \end{array}}$$

Polytropic: pV^n = constant $\qquad$ n a polytropic exponent (not number of moles)

$$\boxed{\begin{array}{l} {}_1W_2 = \dfrac{p_2V_2 - p_1V_1}{1-n} \\ \text{if polytropic } n \neq 1 \end{array}}, \qquad \boxed{\begin{array}{l} {}_1W_2 = p_1V_1 \ln \dfrac{V_2}{V_1} \\ \text{if } pV = \text{constant (i.e. } n=1) \end{array}}$$

$\boxed{\text{For ideal gas } pV = mRT}$

4.42

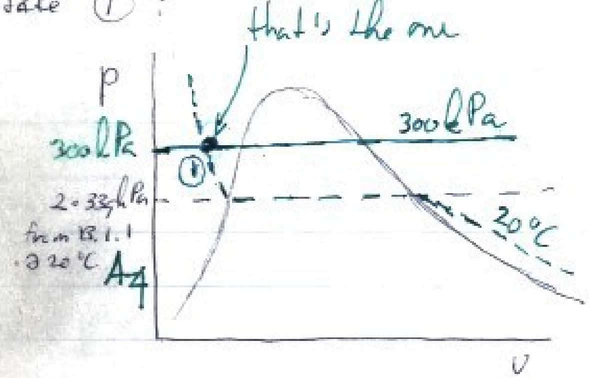


can find v_1 and then V_1!

$_1W_2 = \frac{p_2 + p_1}{2}(V_2 - V_1)$

can find $v_2 = V_2/m_2$!

Solution: start of pv diagram and use broken line first to find state ①:

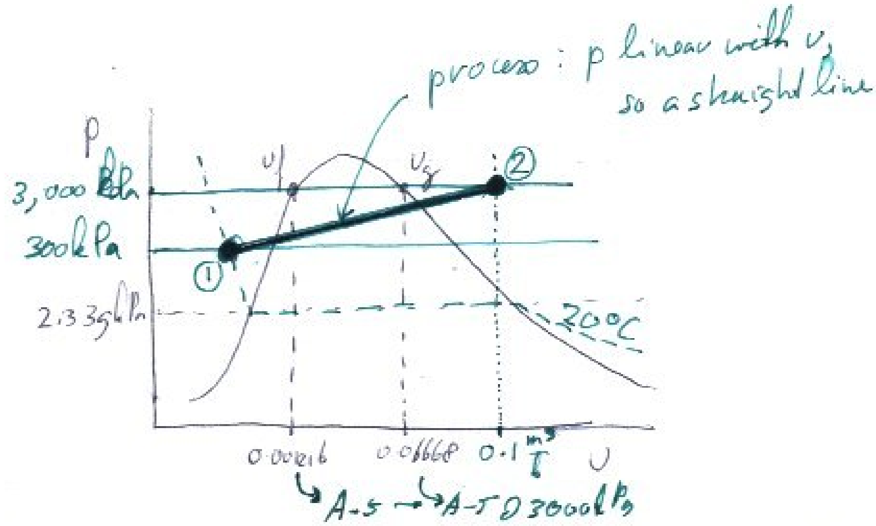


Look up 300kPa and 20°C in B.1.4 (A-7). Oops, not there.
Instead look up 20°C in B.1.1 (A-4) $\rightarrow$ $v_1 = v_f @ 20°C = 0.001002\ m^3/kg$
$V_1 = m_1 v_1 = 0.001002\ m^3$.

~~Complete~~ Find v_2: $v_2 = V_2/m_2 = 0.1\ m^3/1kg = 0.1\ \frac{m^3}{kg}$

Now complete the pv diagram, by finding ② given p_2 and v_2

$p_2 \downarrow$ 3MPa $\quad v_2 \downarrow$ $0.1\ \frac{m^3}{kg}$



2/2/06 end →

Work: $_1W_2 = \frac{p_2 + p_1}{2}(V_2 - V_1) = \frac{(3000 + 300)\ kPa}{2}(0.1 - 0.001002)\ m^3$

$= 163.35\ kJ$

A-6

Temperature T_2: look up superheated vapor in B.1.3

@ 3000 kPa (≤ 3MPa) and $v_2 = 0.1\ m^3/kg$

$g = 0.1\ m^3/kg$ $\quad g_1 = 0.09936$ $\quad g_2 = 0.10787$

$d_1 = 400\ °C$ $\quad d_2 = 450\ °C$

$T = 400°C + \frac{0.1 - 0.09936}{0.10787 - 0.09936}\ \frac{m^3/kg}{m^3/kg}\ (450 - 400)\ °C$

$= \underline{404\ °C}$