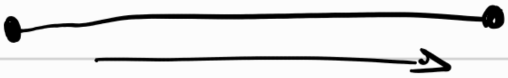
1) a)  l, ~~m~~, t

temperature

b) g $\quad f(l, T, t) = 0$ or $f(l, T, t, d) = 0$

c) 2 ✓

2) $f(x, y, z) = 0$

a) $$\left(\frac{\partial x}{\partial y}\right)_z = \frac{1}{(\partial y / \partial x)_z}$$

$$\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial x}\right)_z = 1$$

$$\left(\frac{\cancel{\partial x}}{\cancel{\partial x}} \; \frac{\cancel{\partial y}}{\cancel{\partial y}}\right)_z = 1$$

for

$f(x, y, z) = 0 \rightarrow x(y, z)$

$$dx = \left(\frac{\partial x}{\partial y}\right) dy + \left(\frac{\partial x}{\partial z}\right)_y dz$$

$$\frac{dy}{\partial z} = \left(\frac{\partial y}{\partial z}\right)_x$$

?

$$dy = \left(\frac{\partial y}{\partial x}\right) dx + \left(\frac{dy}{\partial z}\right) dz$$

$\rightarrow$ set $dz = 0$

$$dx = \left(\frac{\partial x}{\partial y}\right)_z dy$$

$$\left(\frac{\partial y}{\partial x}\right)_z dx = dy$$

$$\therefore \; dx = \frac{dy}{(\partial y/\partial x)_z}$$

Thus $\left(\frac{\partial x}{\partial y}\right)_z \cancel{dy} = \frac{\cancel{dy}}{(\partial y/\partial x)_z}$ ✓

b) $\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$

$$dx = \left(\frac{\partial x}{\partial y}\right) dy + \left(\frac{\partial x}{\partial z}\right)_y dz$$

$$dy = \left(\frac{\partial y}{\partial x}\right) dx + \left(\frac{\partial y}{\partial z}\right) dz$$

$$dz = \left(\frac{\partial z}{\partial x}\right) dx + \left(\frac{\partial z}{\partial y}\right) dy$$

$$a \Rightarrow \left(\frac{\partial x}{\partial y}\right)_z = \frac{1}{(\partial y/\partial x)_z}$$

thus $\left(\frac{\partial x}{\partial y}\right)\left(\frac{\partial y}{\partial z}\right) = 1$

$$\therefore \left(\frac{\partial z}{\partial x}\right)_y = -\left(\frac{\partial z}{\partial y}\right) dy + dz \qquad \cancel{dz = 0}$$

$$= \cancel{-\frac{\partial z}{\partial y}} dy$$

~~if z = 0~~

set $dx = 0$

u can set whatever d? is more convenient $= 0$

$$\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$$

$$dx = \left(\frac{\partial x}{\partial y}\right) dy + \left(\frac{\partial x}{\partial z}\right)_y dz = 0$$

$$dy = \left(\frac{\partial y}{\partial x}\right) dx + \left(\frac{dy}{\partial z}\right) dz$$

$$dz = \left(\frac{\partial z}{\partial x}\right) dx + \left(\frac{\partial z}{\partial y}\right) dy$$

$$\left(\frac{\partial x}{\partial y}\right)_z = -\left(\frac{\partial x}{\partial z}\right)_y \frac{dz}{\;}$$

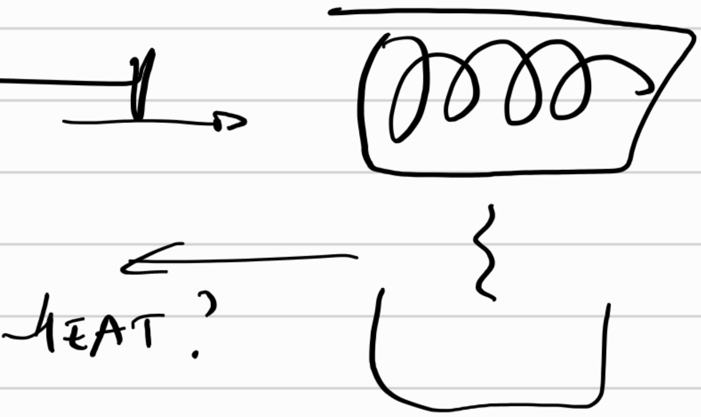
dy

$$\left(\frac{\partial y}{\partial z}\right) = \frac{dy}{dz}$$

$$-\left(\frac{\partial x}{\partial z}\right)_y \left(\frac{\partial z}{\partial x}\right)_y$$

$$= -(1)$$

3) a) 



b) H → ← O

Nah

potential → E

4) $H2: F = y(l - l_0)$

$$\Delta W = \int_{l_1}^{l_2} F \, dl$$

$$= \int_{l_1}^{l_2} y(l - l_0) \, dl$$

$$= y\left[\frac{1}{2}l^2 - l_0 l\right]_{l_1}^{l_2}$$

$$= \frac{1}{2}y l_2^2 - \frac{1}{2}y l_1^2 - y l_0 l_2 + y l_0 l_1$$

$$= \frac{y}{2}(l_2 - l_1)(l_2 + l_1 - 2l_0)$$

5. $F = 4T\left(\frac{l}{l_0} - \frac{l_0^2}{l^2}\right)$

$$\Delta W = \int_{l_0/2}^{l_0} F \, dl = \int_{l_0/2}^{l_0} 4T\left(\frac{l}{l_0} - \frac{l_0^2}{l^2}\right) dl$$

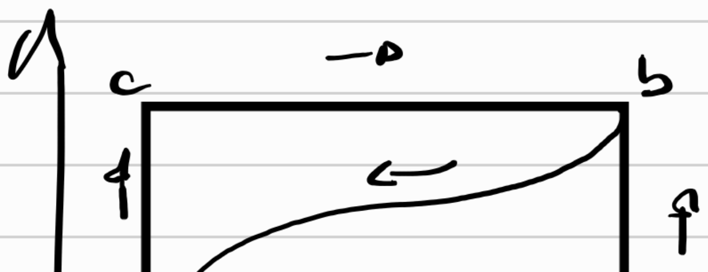
$\int l^{2} dl = \frac{-1}{l}$

$$= 4T\left[\frac{1}{l_0}\int_{l_0/2}^{l_0} l \, dl - l_0^2\int_{l_0/2}^{l_0} l^{-2} \, dl\right]$$

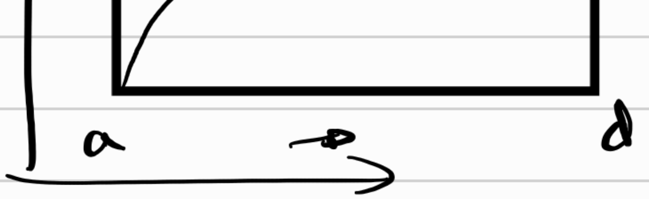
$$= 4T\left[\frac{1}{l_0}\left[\frac{l^2}{2}\right]_{l_0/2}^{l_0} + l_0^2\left[\frac{1}{l}\right]_{l_0/2}^{l_0}\right]$$

$$= 4T\left[\frac{4l_0}{8} - \frac{l_0}{8} + \frac{8l_0}{8} - \frac{16l_0}{8}\right]$$

$$= 4T l_0\left[-\frac{5}{8}\right] = \frac{-5}{8} 4T l_0$$

6. 

acb — 800 J, $w = 300$ J



ads ? $w = 100J$

$$\Delta U = \Delta W + \Delta Q$$

$$\Delta U_{acb} = \Delta U_{adb}$$

$$\Delta W_{acb} + \Delta Q_{acb} = \Delta W_{adb} + \Delta Q_{adb}$$

$$800 - 300 = -100 + \Delta Q$$

$$\Delta Q = 600\ J \checkmark$$

b) $\Delta U = 500\ J$

$\Delta Q = \Delta U - \Delta W$ $\quad 500 = -200 + \Delta Q$ ~

$$Q = -700\ J \checkmark < 0$$

~~absorbs~~

liberates

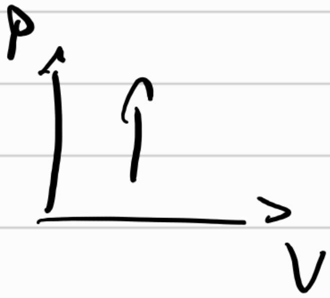
7) $f = aTx$ $\quad T = C\exp\left(\frac{ax^2}{2b}\right)$

$U = bT$

$dU = dQ + f\,dx$

$$U = bC\exp\left(\frac{ax^2}{2b}\right)$$

adiabatic



const V

$$dQ = 0 \implies \Delta U = \Delta W$$

$$\Delta U = \Delta(bT) = \Delta W$$

$$b\Delta T = \Delta W$$

$$b\Delta T = \Delta \int aTx\,dx$$

$$b\Delta T = a\Delta T \int x\,dx$$

$$b = a\int x\,dx$$

$$\implies b\Delta T = b\Delta T$$

8) linear coef. of thermal expansion

$$\alpha = \frac{1}{\ell}\frac{d\ell}{dT}$$

↑ WTF is it?

$$\therefore \ell = \frac{1}{\alpha}\frac{d\ell}{dT}$$

Find it in notes!

if $\alpha = \frac{1}{\ell}\frac{d\ell}{dT} \Rightarrow \frac{1}{\alpha}\frac{d\ell}{dT} = \ell_0 \exp(\alpha \Delta T)$

$$\ell_0 \frac{d\ell}{dT} = \alpha \exp(\alpha \Delta T)$$

α

$\downarrow$

ℓ

$$\alpha\, dT = \frac{1}{\ell} d\ell$$

$$\int \alpha\, dT = \int_{\ell_0}^{\ell} \frac{1}{\ell} d\ell$$

$$\alpha (T - T_0) = \ln(\ell / \ell_0)$$

$$\ell = \ell_0 \exp(\alpha \Delta T)$$

9) Yes ✓ $\alpha = 0$ POSSIBLE

10) $c_1 \int_{T_1}^{T_f} dT = -c_2 \int_{T_2}^{T_f} dT$

$$c_1 (T_f - T_1) = -c_2 (T_f - T_2)$$

$$T_f (c_1 + c_2) = c_1 T_1 + c_2 T_2$$

$T_f = c_1 T_1 + c_2 T_2$

$$\frac{\ldots c_2 \ldots}{c_1 + c_2}$$

11)

$\downarrow$ 100 000

$\bigcirc \longrightarrow$ 254W/h Work

$\downarrow$ 25 000

$1J = 9.5 \times 10^{-4}$ BTU

need to set a unit table in A4!

$$\eta = \frac{\text{work out}}{\text{heat in}}$$

$W = 25\,kW = 9 \times 10^{7} J$

$Q_{in} = 100\,000$ BTU $= 1.05 \times 10^{9} J$

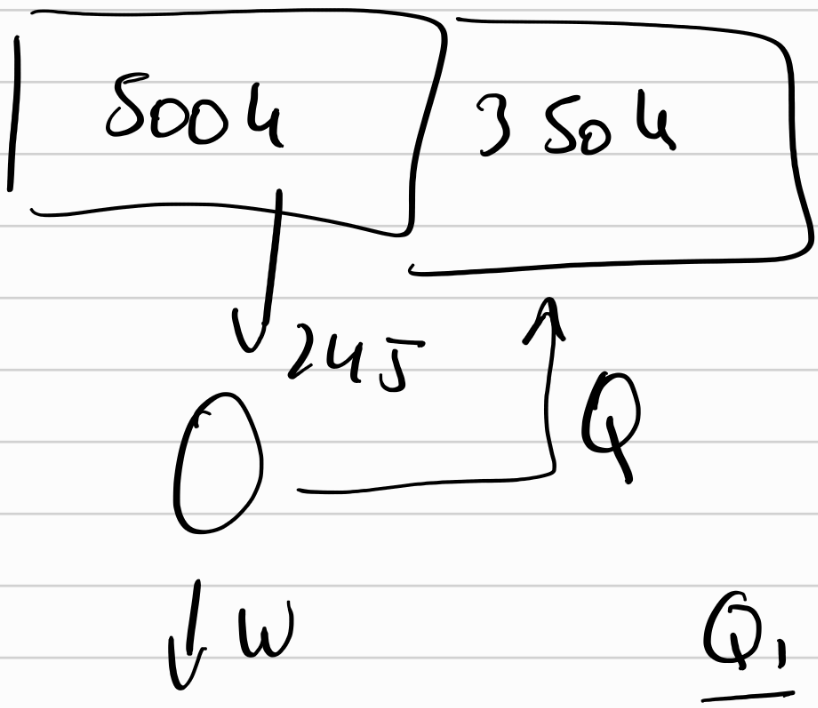
$\eta = \cancel{0.086}$ nope...

$W + Q_{out} > Q_{in}$

look at Q_{out}, not

just w for 1st law violates

12.



$$\frac{T_1}{T_2} = \frac{Q_1}{Q_2}$$

$$\frac{Q_1}{Q_2} = f_1(T_1, T_2)$$

$$W = Q_1 - \{Q_2\}$$