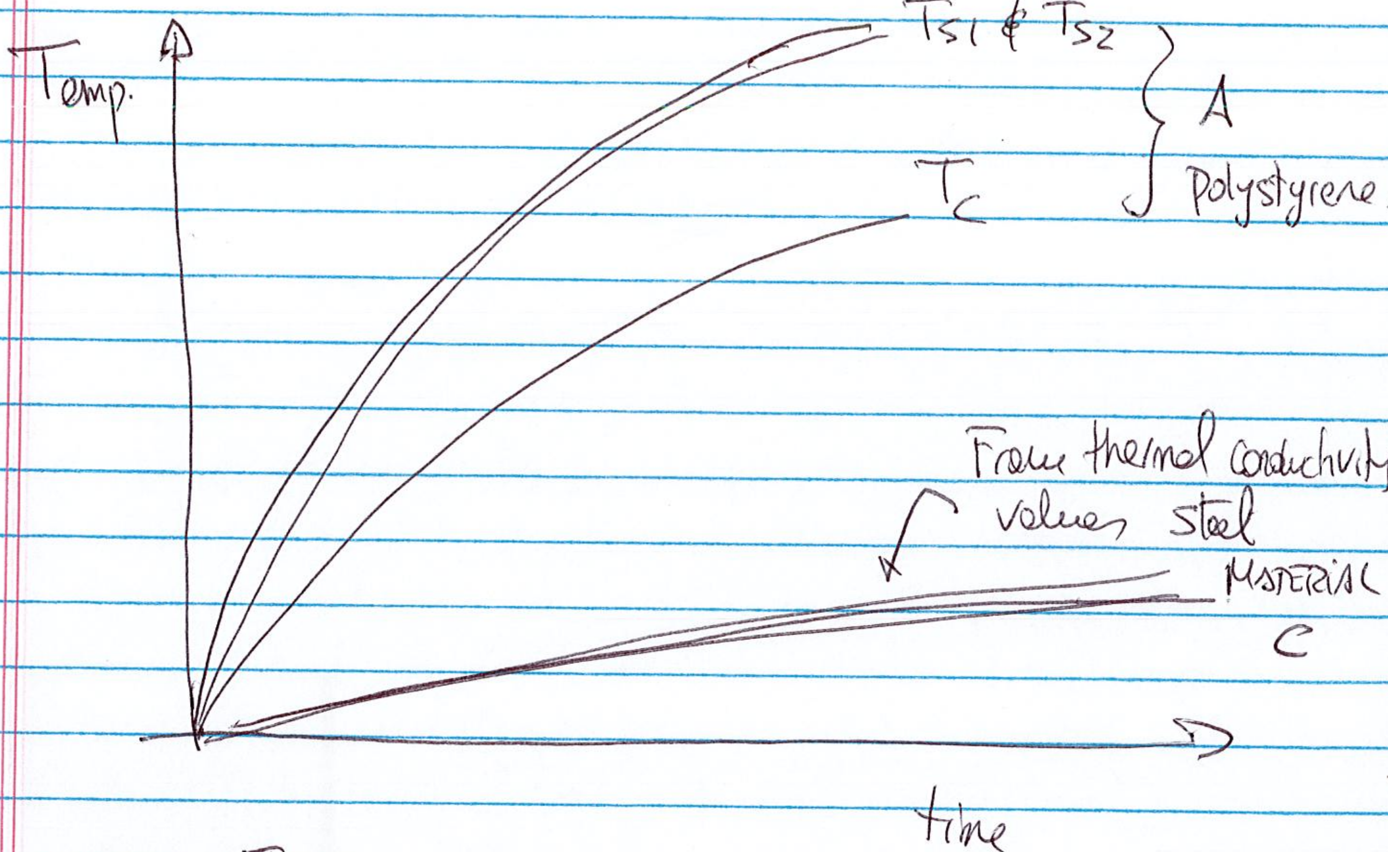
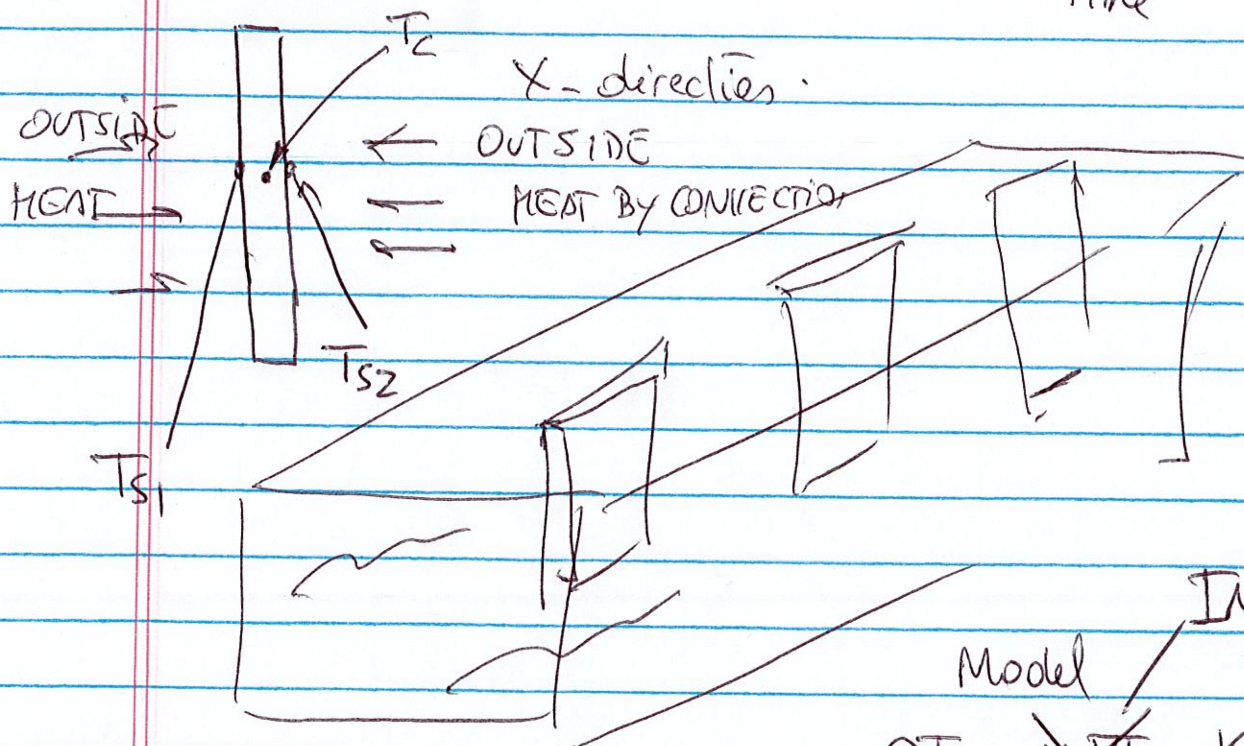
NOTES LECTURE 3-20-2018 1




Model

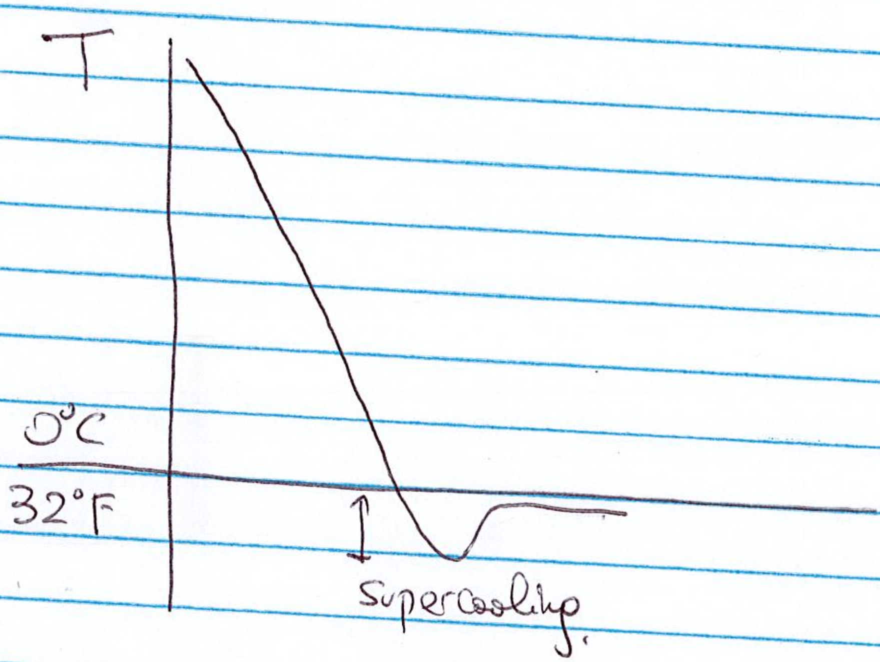
INTERNAL CONVECTION

$$\frac{\partial T}{\partial t} + \cancel{u \nabla T} = k \frac{\partial^2 T}{\partial x^2}$$

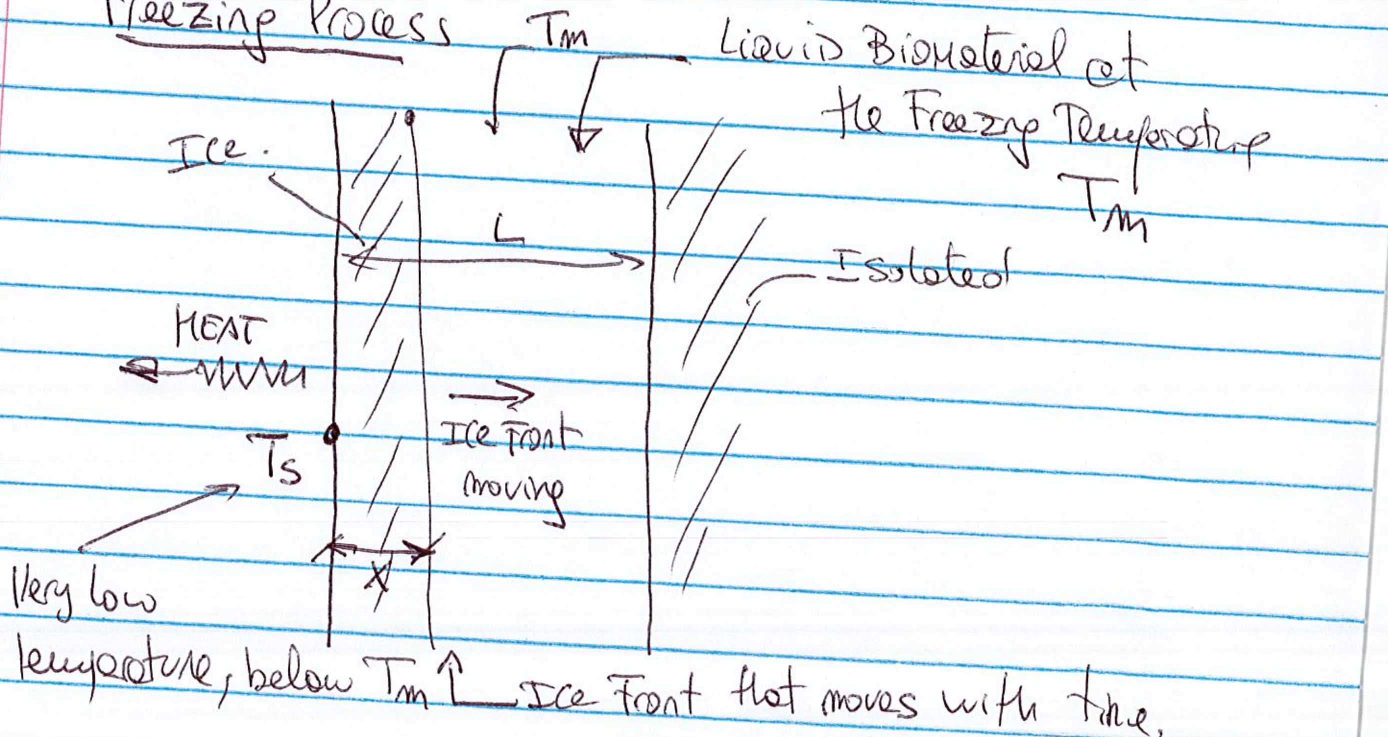
why steel has a slower heating rate?

$\underbrace{\rho C}_{\text{THERMAL INERTIA}}$ → very small for polystyrene.
→ very large for steel

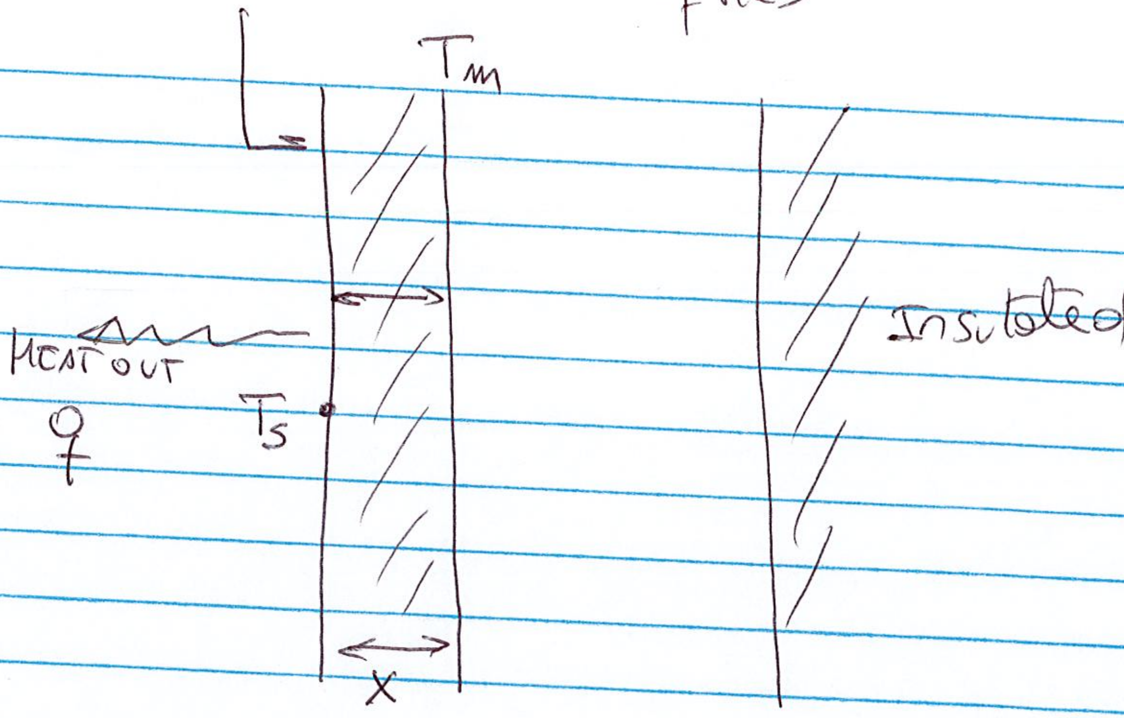
## LECTURE 7




## Freezing Process



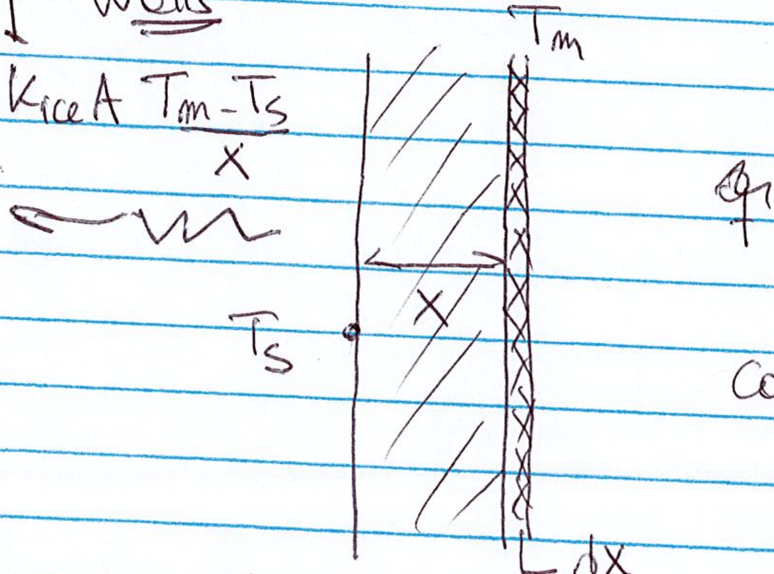
A : cross-sectional area of slab




$$q = \frac{T_m - T_s}{\text{Resistance of the ice layer}} = \frac{T_m - T_s}{\frac{x}{K_{ice} A}}$$

[ Watts

$$q = K_{ice} A \frac{T_m - T_s}{x}$$




Can I calculate or energy to get out after a dx of ice formed.

Units $\frac{W}{\cancel{m}\cdot\cancel{K}} \cdot \cancel{m^2} \cdot \frac{\cancel{K}}{\cancel{m}}$

$$q = K_{ice} A \underbrace{\frac{T_m - T_s}{X}}_{\text{Watts}} = \underbrace{\Delta H_f}_{\frac{J}{kg}} \times \frac{\text{mass of ice formed}}{\text{time}} \quad (4)$$

$$\text{mass of ice per unit time} = \frac{dV \times \rho}{dt} = A \frac{dX}{dt} \rho$$

$$K_{ice} \cancel{A} \frac{T_m - T_s}{X} = \Delta H_f \cancel{A} \rho \frac{dX}{dt}$$

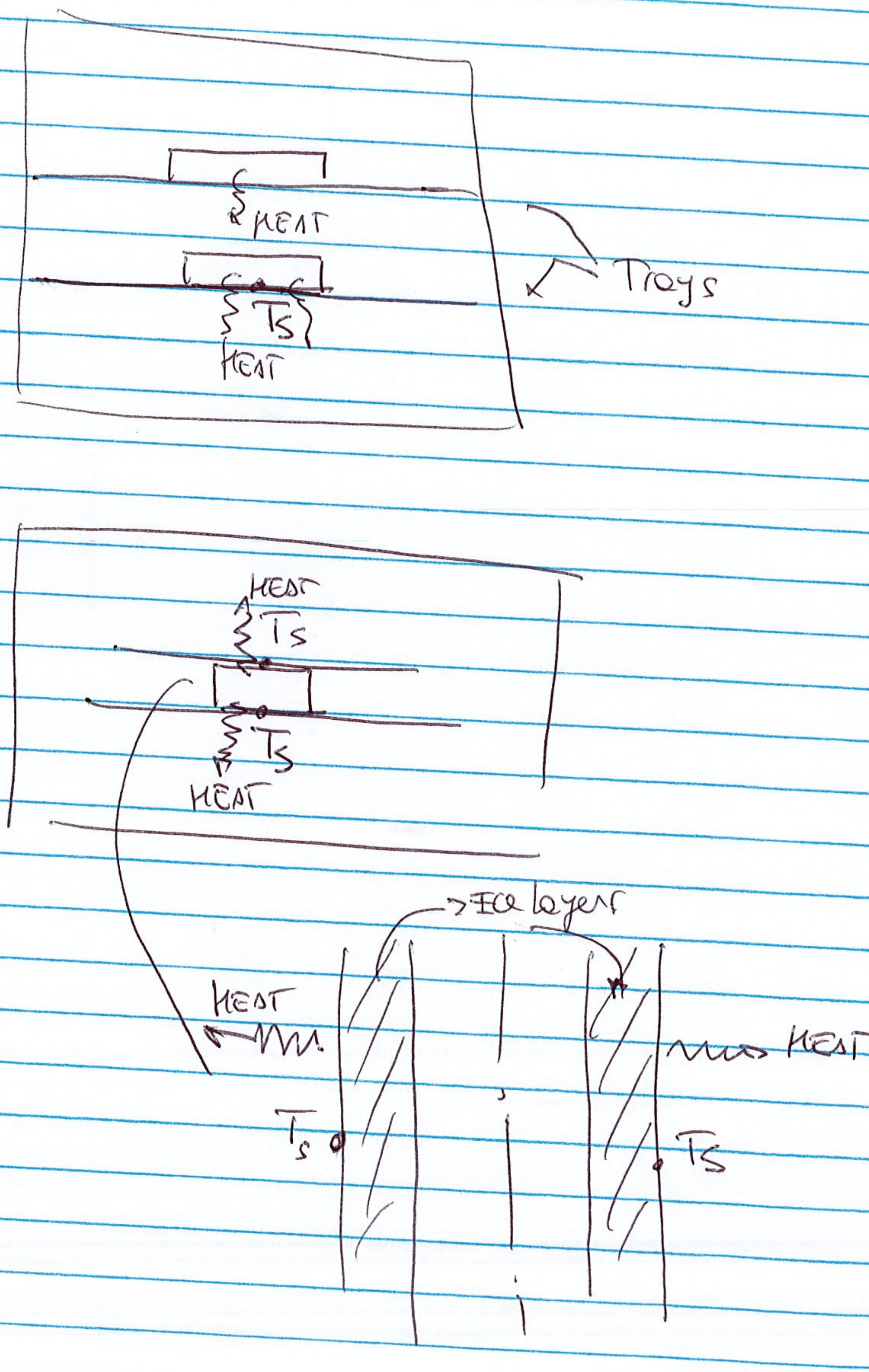
$$\int_0^t \frac{K_{ice}(T_m - T_s)}{\Delta H_f \rho} dt = \int_{X=0}^{X} X dX$$

$$\frac{K_{ice}(T_m - T_s)}{\Delta H_f \rho} t = \frac{X^2}{2}$$

$$\boxed{t = \frac{\Delta H_f \rho}{2 K_{ice}(T_m - T_s)} X^2}$$

# Commercial Freezing Units





what happens when the cooling (6)

is done by cooling air at $T_\infty$ rather

than a cold surface at $T_s$ ?

$$q = \Delta H_f \rho A \frac{dX}{dt}$$

$$\Rightarrow q = \frac{T_m - T_\infty}{\underset{\text{in air}}{\text{Resist convection}} + \text{Resistance in ice layer}}$$

$$\frac{1}{hA} \qquad \frac{X}{KA}$$

$$\frac{T_m - T_\infty}{\frac{1}{hA} + \frac{X}{KA}} = \Delta H_f \rho A \frac{dX}{dt}$$

$$\int \frac{T_m - T_\infty}{\Delta H_f \rho A} dt = \int dX \left[ \frac{1}{hA} + \frac{X}{K_{ice} A} \right]$$