Recap of Thermodynamics Ideas discussed week 2

Open vs Closed thermodynamic system

- Open: mass flow
- Closed: no mass flow

Modes of Heat transfer

Conduction

$$\left[\frac{dQ}{dt}\right] = -k_T A \frac{dT}{dx}$$

- $\frac{dQ}{dt}$: rate of Heat flow; Q: Heat [J]
- k_T: thermal conductivity $\left[\frac{W}{mK}\right]$ ← engineering tool box is a good resource as is CRC hand book of Physics and Chemistry
- A: cross sectional area [m^2]
- dT: temperature; dx: position through material. Together, $\frac{dT}{dx}$ is the thermal gradient

Resistance to heat flow

$$R \equiv \frac{L}{K_T}$$

- L ← thickness of material
- K_T ← thermal conductivity

SI	Imperial
$\left[\frac{m^2 K}{W}\right]$	$\left[\frac{ft^2 \, {}^\circ F}{BTU/hr}\right]$

↑ implicit units for R on const. materials in US.

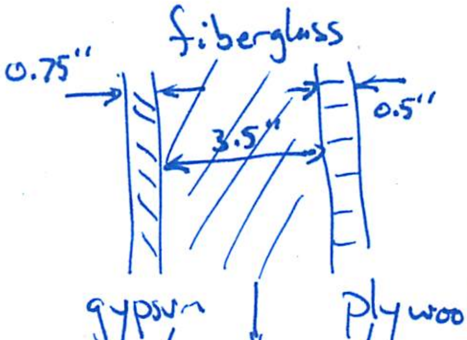
- BTU ≡ heat to warm 1 lb of H_2O 1°F

larger R ⇒ better insulator
either thicker insulation
or lower thermal conduction

Efficient Conversion of k_T from SI → Imperial

$$1 \frac{W}{mK} \times \frac{1\,BTU}{1055\,Ws} \frac{3600\,s}{hr} \times \frac{5°C}{9°F} \times \frac{1\,m}{3.28\,ft} = 0.5778 \frac{BTU/hr}{ft°F}$$

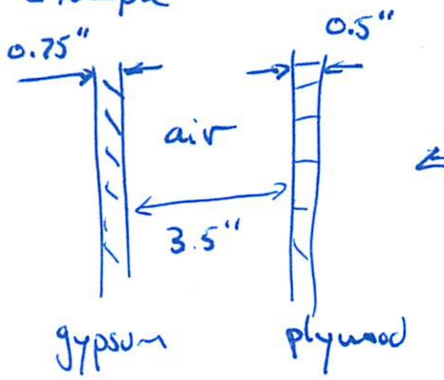
Note that R-values of an assembly add



$$R_g + R_f + R_p = R_{wall}$$

Note that the value of R can be miss leading if other modes of Heat transfer are relevant

Example



this wall has a lower R value due to conduction than the wall containing Fiberglass above ($k_{T_{air}} < k_{T\,fibreglass}$)

But rate of Heat Flow is greater w/ air due to convection

Convection

$$\frac{dQ}{dt} = h A (T_s - T_\infty)$$

- h — convection coeff.
- A — area of surface
- T_s — temp of surface
- T_∞ — air temp far from surface