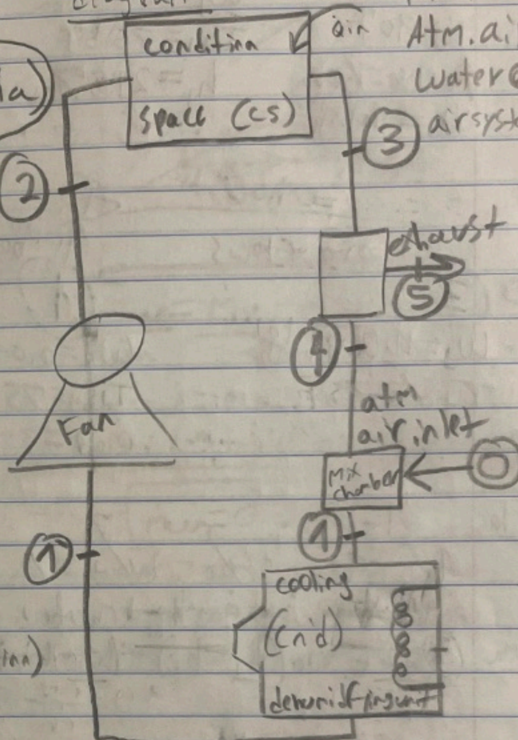
Test 3 Nathan Chrays & Brad Etheridge

problem 1

diagram:



Materials:
Atm. air @ 90°F
water @ 55°F
air system @ 75°F

purpose: * quantity of air to CS ($\dot{m}_a$)
* State of air finding "ω" and "T_{db}"
* Drawn on psychrometric chart
* capacity of dehumidifying unit $\dot{m}_w$

Data: given
$\dot{V}_{exhaust} = 500\ ft^3/min$
$\dot{V}_{in\,air} = 500\ ft^3/min$
$T_{db} = 75°F \quad T_{air\,in} = 90°F$
$\phi_{cs} = 50\% \quad \phi_{outside} = 60\%$
$\dot{Q}_{in} = 72{,}000\ btu/hr$

assumptions:
- constant mixing in (cnd) unit
- humidity ratio in (CS) constant
- dehumidifying is ideal behavior
- fan is ideal (no Δ in air condition)

procedure:
1) States w/ Diagram
2) psychrometric chart → mark points, 0, 3, 4, 5, 2, 1 → Find 1
3) calculations → 1st laws → conservation of mass → Humidity ratio → 1st law
4) Solutions

Summary:
In problem 1, focusing on the conditioned space part of the air conditioning as a whole. as the cycle functions air (0) mixes w/ the air of the previous cycle (4) to combine and flow into a dehumidifier and cooling unit to the point where the dew point temp is reached and continues to cool into a fan and then into the confined space, having cold air enter to maintain a constant Temp. and relative humidity to balance the heat entering the room (conditioned space). after conditioned air leaves and heat is released outside into the atmosphere before accepting atmospheric air.

(2)

(0) $\xrightarrow{\text{mixing box}}$ (1) $\xrightarrow[\text{dehumidify}]{\text{cooling}}$ (1') $\xrightarrow{\text{Fan}}$ (2) $\xrightarrow{\text{Condition space}}$

$\dot{Q}_{in} = 72000 \ \frac{btu}{hr}$

(0)

$T_{db0} = 90°F$

$\phi_{outside} = 60\%$

$\omega_0 = 0.018 \frac{lbv}{lba}$

(1)

$\omega_1 = 0.01026 \frac{lbv}{lba}$

$T_{db1} = 76.5°F$

$h_1 = 29.5 \ btu/lba$

(1')

$\omega_{1'} = 0.0091 \frac{lbv}{lba}$

$T_{db1'} = 55°F$

$h_{1'} = 23 \ btu/lba$

(2)

$\omega_2 = 0.0091 \frac{lbv}{lba}$

$T_{db2} = 55°F$

$h_{2a} = 23 \ btu/lba$

(3) $\xrightarrow{\text{air flows}}$ (4) $\xrightarrow{\text{mixing box}}$ (1) $\rightarrow$ (5)

(3) $\xrightarrow{\text{exhaust}}$ (1)

(3)

$\omega_3 = 0.0091 \frac{lbv}{lba}$

$T_{db3} = 75°F$

(4)

$\omega_4 = 0.0091 \frac{lbv}{lba}$

$T_{db4} = 75°F$

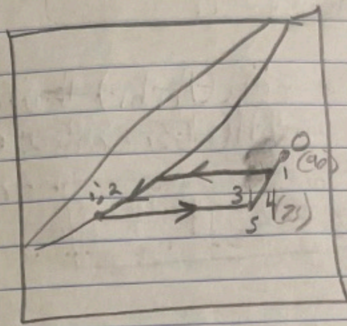
$\dot{m} = 383 \ \frac{lba}{\ldots}$

(5)

$\omega_5 = 0.0091 \frac{lbv}{lba}$

$T_{db5} = 75°F$

Calculations:



1st law (2-3), $\dot{m}_{a2} = \dot{m}_{a3}$

$q_{in} - q_{out} + w_{in} - w_{out} = \Delta h$

$\dot{Q}_{in} = \dot{m}_{a3} \cdot h_3 - \dot{m}_{a2} \cdot h_2$

1st law (1-1')

dehumidification & cooling

$q_{in}^{0} - q_{out} + w_{in}^{0} - w_{out}^{0} = \Delta h + h_w$

$\frac{\dot{Q}_{out}}{\dot{m}_a} = \frac{\dot{m}_a(h_1 - h_2) - (\dot{m}_w \cdot h_w)}{\dot{m}_a}$

$q_{out} = h_1 - h_{1'} - (\omega_1 - \omega_{1'}) h_\omega$

$\frac{\dot{m}_w}{\dot{m}_a} = \frac{\dot{m}_{v1} - \dot{m}_{v1'}}{\dot{m}_a} \rightarrow \omega_1 - \omega_{1'}$

$\dot{m}_w = \dot{m}_a(\omega_1 - \omega_{1'})$

$h_w \rightarrow$ tables at $T_{db} = 55°F$

$\boxed{\dot{m}_w = 0.00515 \frac{lbv}{s}}$

(2-3) cart, psychrometric chart

$\dot{Q}_{in} = \dot{m}_a(h_3 - h_2)$

$h_3 = 27.5 \frac{btu}{lba}$ $h_2 = 23 \frac{btu}{lba}$

$\frac{20 \frac{btu}{s}}{4.5 \frac{btu}{lba}} = \dot{m}_a = 4.44 \frac{lba}{s}$

$\dot{m}_{a3} = \dot{m}_{a4} + \dot{m}_{a5}$

Mass flow rates, psychrometric chart

$\dot{m}_{a5} = \frac{1}{v_5} \cdot \dot{V} = \frac{1}{13.66 \frac{ft^3}{lba}} \cdot 8.33 \frac{ft^3}{s}$

$v_5 = 13.66$ $\dot{V} = 500 \frac{ft^3}{min} = 8.33 \frac{ft^3}{s}$

$\dot{m}_{a5} = 0.61 \frac{lba}{s}$

$\dot{m}_{a1} = \dot{m}_{a0} + \dot{m}_{a4}$

$\dot{m}_{a4} = \dot{m}_{a3} - \dot{m}_{a5}$

$= 4.44 \frac{lba}{s} - 0.61 \frac{lba}{s}$

$\dot{m}_{a4} = 3.83 \frac{lba}{s}$

$\dot{m}_{a0} = \frac{1}{v_0} \cdot \dot{V} = \frac{1}{14.25} \cdot 8.33 \frac{ft^3}{s}$

$v_0 = 14.25 \frac{ft^3}{lba}$ $\dot{V} = 8.33 \frac{ft^3}{s}$

$\dot{m}_{a0} = 0.585 \frac{lba}{s}$

$\dot{m}_{a4} + \dot{m}_{a0} = 4.42 \frac{lba}{s}$

Mixing box $\rightarrow \frac{\dot{m}_{a4}}{\dot{m}_{a0}} = \frac{\omega_0 - \omega_1}{\omega_1 - \omega_4} \rightarrow \omega_1 = \frac{\dot{m}_{a4} \cdot \omega_4 + \dot{m}_{a0} \cdot \omega_0}{\dot{m}_{a4} + \dot{m}_{a0}}$

$\omega_4 = .0091 \frac{lbv}{lba}$ $\omega_0 = 0.018 \frac{lbv}{lba}$

$\omega_1 = \frac{(3.83 \frac{lba}{s} \cdot 0.0091 \frac{lbv}{lba}) + (0.585 \frac{lba}{s} \cdot 0.018 \frac{lbv}{lba})}{4.42 \frac{lba}{s}}$

$\omega_1 = 0.01026$

Sources:
thermodynamics an engineering approach,
Ayala Notes / Slides

$\rightarrow$

sources
- Ayala,
- thermodynamics an engineering approach
- notes/slides

Calculations cont.

1st law (1-1')

Dehumidifier

$h_w = 23.07\ \frac{btu}{lbv}$

$h_1 = 24.5\ \frac{btu}{lba}$

$h_{1'} = 23\ \frac{btu}{lba}$

$\dot{Q}_{out} = \dot{m}_a (h_1 - h_{1'}) + \dot{m}_a (\omega_1 - \omega_{1'}) h_w$

$= 4.44 \frac{lba}{s} (24.5 - 23) \frac{btu}{lba} + 4.44 \frac{lba}{s} \left(0.01026 \frac{lbv}{lba} - 0.0091 \frac{lbv}{lba}\right) \times 23.07 \frac{btu}{lbv}$

$\boxed{\dot{Q}_{out} = 28.978\ \frac{btu}{s}}$

Solutions: Problem 1

1	1'	2	3	4
$T_{db1} = 76.5°F$	$T_{db1'} = 55°F$	$T_{db2} = 55°F$	$T_{db3} = 75°F$	$T_{db4} = 75°F$
$\omega_1 = 0.01026 \frac{lbv}{lba}$	$\omega_{1'} = 0.0091 \frac{lbv}{lba}$	$\omega_2 = 0.0091 \frac{lbv}{lba}$	$\omega_3 = 0.0091 \frac{lbv}{lba}$	$\omega_4 = 0.0091 \frac{lbv}{lba}$

5	0
$T_{db5} = 75°F$	$T_{db} = 90°F$
$\omega_5 = 0.0091 \frac{lbv}{lba}$	$\omega_0 = 0.018 \frac{lbv}{lba}$

Technical analysis:

Based on the system as it stands it will function fine, but, with changes to the outside temp., the heat gained inside the room or a change to the cooling and dehumidifying unit; the system may break or not function. For example, if the outside temp and humidity change the air at the mixing chamber may be too cool to enter the rest of the system making the temp. too cold. If the gain changes, the room may be too warm. This system relies on a balance and does not seem very adoptive, in case of these issues, a possible fix could be adding in a temp. sensitive humidifier in case it gets too cold, or if it is too hot, increasing the efficacy of the cooling and dehumidifying unit to expel more heat.

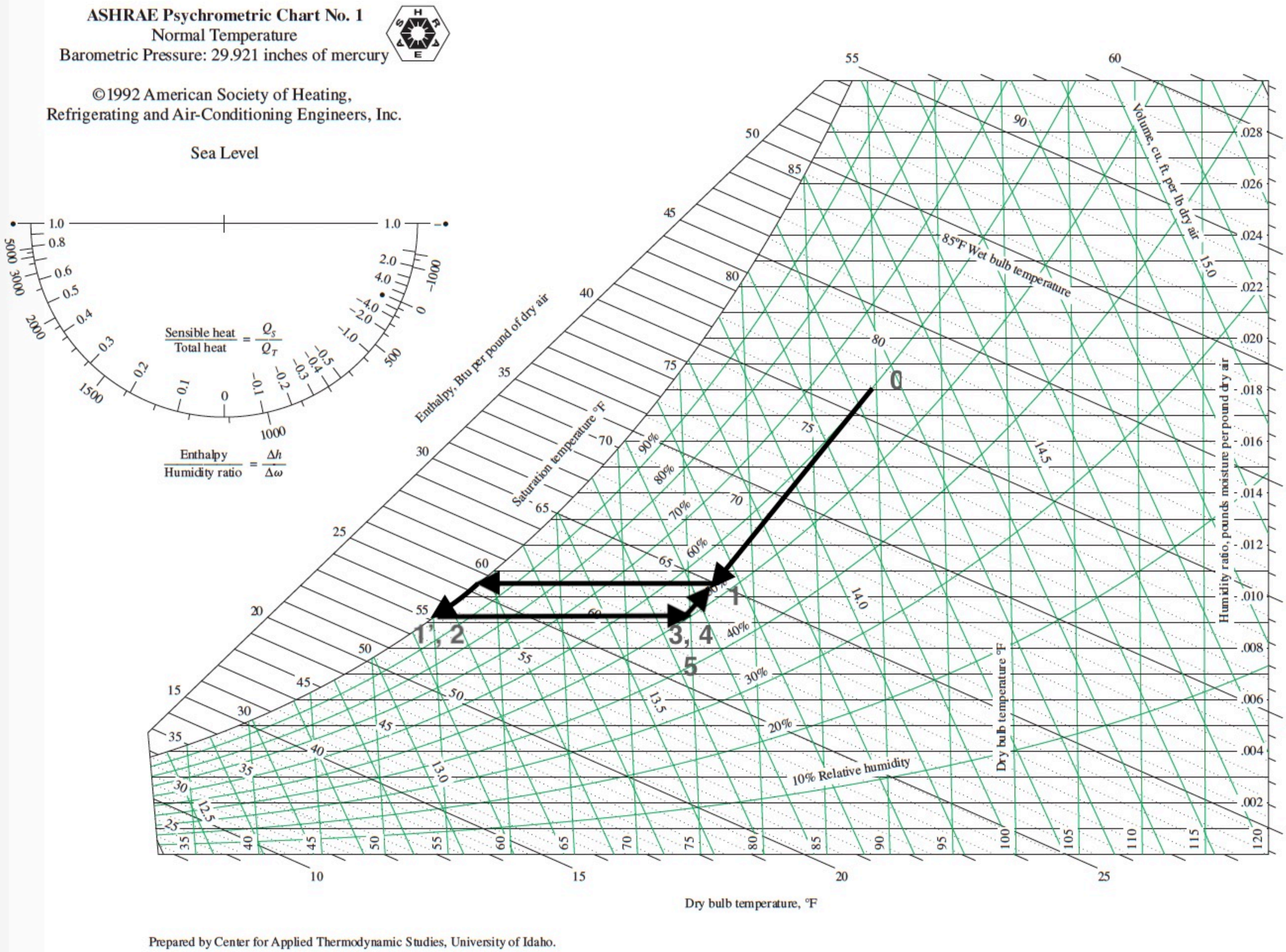


FIGURE A–31E

Psychrometric chart at 1 atm total pressure.

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