{Question 5E}

$UnitSystem ENG
T_1=35[F]
P_1=60[psi]
T_2=160[F]
P_2=170[psi]
T_3=80[F]
P_3=170[psi]
P_4=60[psi]

T_1water=55[F]
T_2water=40[F]
rho_water= 62.4[lb_m/ft^3] {assume density of water}

T_1air=70[F]
T_2air=100[F]
rho_air= 0.763[lb_m/ft^3] {assume density of air}

Qdot_out=3.8[tons]

{Part a}
h_1air=**enthalpy**(*Air*,*T*=T_1air)
h_2air=**enthalpy**(*Air*,*T*=T_2air)
h_2=**enthalpy**(*R22*,*T*=T_2,*P*=P_2)
h_3=**enthalpy**(*R22*,*T*=T_3,*P*=P_3)

Qdot_out***convert**(tons, Btu/min)=mdot_air*(h_2air-h_1air)
Vdot_air=mdot_air/rho_air {Volumetric Flow Rate of the Heated Air: Vdot_air = 138.3 ft^3/min}

{Part b}
h_1=**enthalpy**(*R22*,*T*=T_1,*P*=P_1)
s_1=**entropy**(*R22*,*T*=T_1,*P*=P_1)
s_2s=s_1
P_2s=P_2
h_2s=**enthalpy**(*R22*,*P*=P_2s,*s*=s_2s)
efficiency_isentropic=(h_2s-h_1)/(h_2-h_1) {Turbines Isentropic Efficiency: efficiency_isentropic = 65.15%}

{Part c}
Qdot_out***convert**(tons, Btu/min)=mdot_r22*(h_2-h_3)
Wdot_compressor=mdot_r22*(h_2-h_1)***convert**(Btu/min, hp) {Compressor Power: Wdot_compressor = 3.397 hp}

{Part d}
h_4=h_3
T_4=**temperature**(*R22*,*P*=P_4,*h*=h_4)
COP=Qdot_out***convert**(tons,hp)/Wdot_compressor {Coeffecient of Preformance: COP = 5.276}

{Part e}
h_1water=**enthalpy**(*Water*,*T*=T_1water,*x*=0)
h_2water=**enthalpy**(*Water*,*T*=T_2water,*x*=0)
mdot_r22*(h_1-h_4)=mdot_water*(h_1water-h_2water)
Vdot_water=mdot_water/rho_water***convert**(ft^3/min,gal/min) {Volumetric Flow Rate of Water: Vdot_water = 4.909 gal/min}

{Part f}
efficiency_carnot=1-(**converttemp**(F,R,T_1water)/**converttemp**(F,R,T_1air)) {Carnot Efficiency: efficiency_carnot = 2.832%}

SOLUTION
Unit Settings: Eng F psia mass deg

COP = 5.276	efficiency$_{carnot}$ = 0.02832
efficiency$_{isentropic}$ = 0.6515	h$_1$ = 175.4 [Btu/lb$_m$]

$h_{1air} = 126.7$ [Btu/lb$_m$]

$h_2 = 193.1$ [Btu/lb$_m$]

$h_{2s} = 186.9$ [Btu/lb$_m$]

$h_3 = 99.96$ [Btu/lb$_m$]

$mdot_{air} = 105.5$ [lb$_m$/min]

$mdot_{water} = 40.95$ [lb$_m$/min]

$P_2 = 170$ [psi]

$P_3 = 170$ [psi]

$Qdot_{out} = 3.8$ [tons]

$\rho_{water} = 62.4$ [lb$_m$/ft^3]

$s_{2s} = 0.4246$ [Btu/lb$_m$-R]

$T_{1air} = 70$ [F]

$T_2 = 160$ [F]

$T_{2water} = 40$ [F]

$T_4 = 21.96$ [F]

$Vdot_{water} = 4.909$ [gal/min]

$h_{1water} = 23.07$ [Btu/lb$_m$]

$h_{2air} = 133.9$ [Btu/lb$_m$]

$h_{2water} = 8.032$ [Btu/lb$_m$]

$h_4 = 99.96$ [Btu/lb$_m$]

$mdot_{r22} = 8.161$ [lb$_m$/min]

$P_1 = 60$ [psi]

$P_{2s} = 170$ [psi]

$P_4 = 60$ [psi]

$\rho_{air} = 0.763$ [lb$_m$/ft^3]

$s_1 = 0.4246$ [Btu/lb$_m$-R]

$T_1 = 35$ [F]

$T_{1water} = 55$ [F]

$T_{2air} = 100$ [F]

$T_3 = 80$ [F]

$Vdot_{air} = 138.3$ [ft^3/min]

$Wdot_{compressor} = 3.397$ [hp]

No unit problems were detected.

EES suggested units (shown in purple) for P_2s s_1 s_2s T_4 .