HW 4 Solution

1) See class notes Week 4 Thursday Feb 2. Solution is given verbatim

2) In this problem a falling machine is raising the water of the tank. You must arrange your equations to relate the energy released from the falling machine to energy that is resulting in increased thermal energy of the water.

Energy released from falling is best described by change in potential energy

potential energy of the machine = *Mgh* where M is mass, g is gravitational constant and H is height.

Change in potential energy = *Mg*Δ*h*

that released potential energy is converted through the propeller and water viscosity into thermal energy of water

Change in thermal energy = M(Δ*H*) *where H is enthalpy.*

To relate enthalpy to temperature you can define enthalpy in terms of temperature and specfic heat

$\Delta H = C_p \Delta T$

subbing everythign in you get

$Mg\Delta h = M(C_p\Delta T)$

$1kg * 9.8\ m/s^{2} * 1\ meter = 1000g * 4.186\ J\ g^{-1}K^{-1}\Delta T$

ΔT = 0.00234 K

Answer is same with celsius, make sure you use proper units to go with your constants.

Derivation from large equation:
System is adibiatic – no external heat
System is closed.
Check the note from Jan 31 for further details.

3) The problem gives you a cost per kilowatthour, which is a unit of energy. So we need to find the amount of energy being used. The easiest way to do this is to focus on the air compressor that is doing the intake. Start with the master equation and manipulate it to be able to solve for the energy done by that air compressor. See. Jan 31 class notes compressor problem.

This results in

$Q + Ws = \Delta m(\hat{H}_2 - \hat{H}_1)$

$\Delta \hat{H} = C_p \Delta T$

$Q + Ws = \Delta m C_p \Delta T$

time to substittue in values for the right half of the equation.

Problem gives you Cp = 30 J/(mol * K)
remember specific heat can be given in K or degrees celsius interchangably

Temperature change should be easy ΔT = 25 - -50 = 75 degrees celsius (or 298-223 = 75K)
now you need Δm

remember we have framed this as a closed system. At the beginning of the system no air has been compressed. So $m_1 = 0$. so we only need to find m_2
What m_2 should we find? The easiest thing is to compress enough air to fill up the plane.

So how do we find that quantity of air? If we act as if air is an ideal gas we can solve for amount of air using the ideal gas law

PV = nRT
what values do we input here? Well which situation do we have more values for? Air before it is compressed we have temperature and pressure but we don't have the volume. For the post-compressed air we have pressure, temperature and volume
(.8 bar) (100m^3) = n(8.314*10^-5 m^3bar/(K*mol))(298K)
n = 3228.9 mols.

You can convert mols to mass by looking up molecular weight of air (29 g/mol)

Or you can look at your Cp constant and realize based on the units that you are better off using mols.

You can then convert your $\Delta m C_p \Delta T$ to the molar version $\Delta n C_p \Delta T$

so (3228.9 mols)*(30 J/(Kmol))*(75K) = 7265025 J

You have solved the right side of the equation.

For the left side you don't need to do anything because Q + Ws combine for the change in internal energy (hence the equation Q + Ws = total internal energy = dU/dt)

Joules need to be converted to Kilowatt hours. Look up conversion rate. 7265025 J = 2.02 kWh

@ 20 cents per kWh

price is $0.40/min

****we solved for the amount of air to fill up the plane the question tells us that happens per minute.**