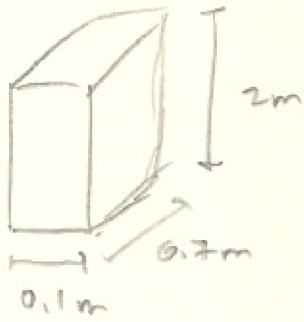
EX calculate thermal resistance through a plane wall, with $k = 0.8$, 2m high, 0.7m wide and 10cm thick, if the outer surface temp is kept a 30°C and the inner is kept a 50°C



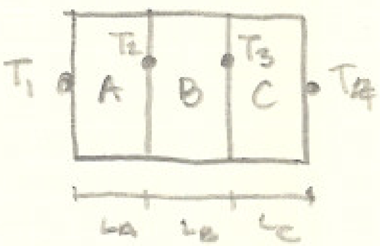
ANALYSES: This is a pure conduction problem the thermal resistance for conduction across the thickness of the wall is.

$$R_{COND} = \frac{L}{kA} = \frac{0.1}{0.8 \cdot 1.4} = 0.089\ K/W$$

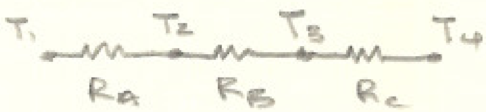
note:

$$\dot{Q}_{COND} = \frac{\Delta T}{R} = \frac{30°}{0.089} = 224.7\ W$$

EX. Consider the composite plane wall shown, that is composed of A, B, C



Since $T_1 > T_4 \Rightarrow$ heat by conduction takes place. The flow of heat $\dot{Q}_{COND}$ and thermal resistances for the composite wall takes the form



under steady state conditions.

$$\dot{Q} = \frac{\Delta T_A}{R_A} = \frac{\Delta T_B}{R_B} = \frac{\Delta T_C}{R_C} = \frac{\Delta T_{TOT}}{R_{TOT}}$$

* will not be given in exam

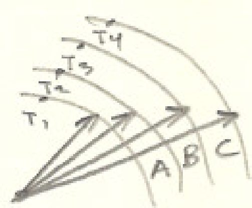
where $\Delta T_A = T_1 - T_2$; $R_A = \frac{L_A}{k_A A_A}$

$\Delta T_B = T_3 - T_2$; $R_B = \frac{L_B}{k_B A_B}$

$\Delta T_C = T_4 - T_3$; $R_C = \frac{L_C}{k_C A_C}$

$\Delta T_{TOT} = T_1 - T_4$; $R_{TOT} = \Sigma R$

COMPOSITE WALL IN CYLINDRICAL SHAPE:



r_1, r_2, r_3, r_4

THE thermal resistances for this series arrgument takes the form.

again;

$$\dot{Q} = \frac{\Delta T_A}{R_A} = \frac{\Delta T_B}{R_B} = \frac{\Delta T_C}{R_C} = \frac{\Delta T_{TOT}}{R_{TOT}}.$$

where

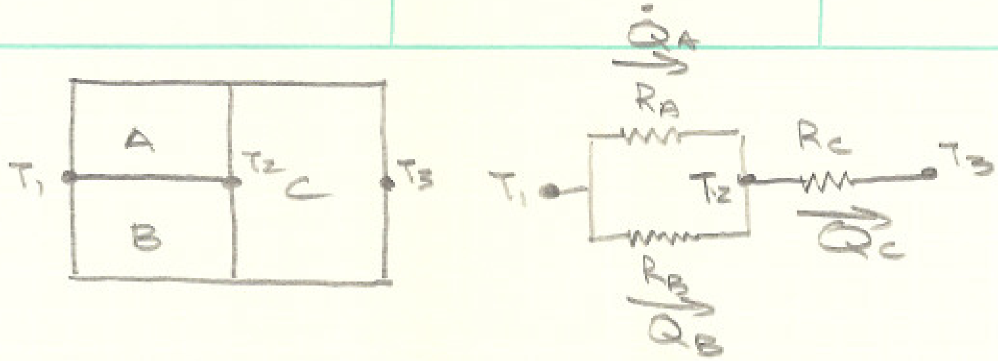
$$\Delta T_A = T_1 - T_2 \; ; \; R_A = \frac{\ln(r_2/r_1)}{2\pi k_A L_A}.$$

and so on.

CONDUCTION IN SERIES/PARALLEL ARGUMENT.

Consider the composite of plane wall consists of different materials; A, B, C as shown in fig

The thermal resistences associated with this configuration is shown in figure



$$\dot{Q} = \dot{Q}_A + \dot{Q}_B = \dot{Q}_C$$

$$\dot{Q}_A = \frac{T_1 - T_2}{R_A}$$

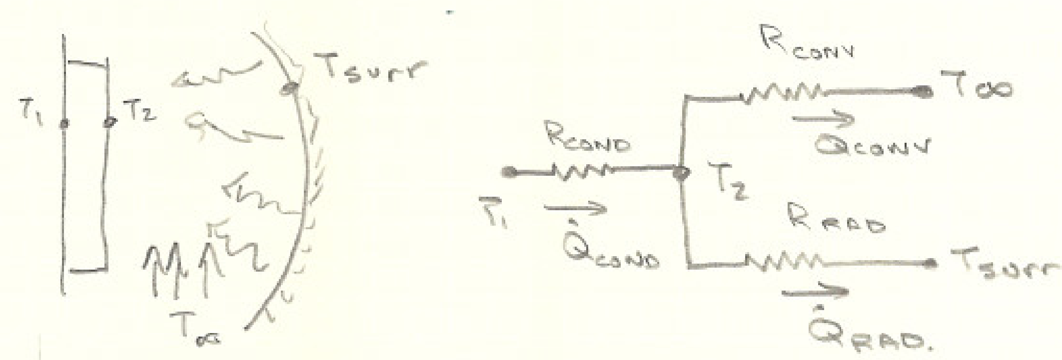
$$\dot{Q}_B = \frac{T_1 - T_2}{R_B}$$

$$\dot{Q} = \frac{\Delta T_{TOT}}{R_{TOT}} = \frac{\Delta T_{TOT}}{R_{PARALLEL} + R_{SERIES}}$$

$$R_{PARALLEL} = \frac{1}{\frac{1}{R_A} + \frac{1}{R_B}} \qquad R_{series} = R_C$$

ANALYSIS OF COMBINED HEAT TRANSFER USING THERMAL RESISTANCE METHOD.

consider the plane wall exposed to convection and radiation as shown. Here, since there is temperture differense, heat transfers flow through the wall, then this heat is lost to the surroundings by convection. There is also, exchenge of heat with the surroundings by thermal radiation. Thermal resistance method yeilds.



$$\dot{Q}_{COND} = \dot{Q}_{CONV} + \dot{Q}_{RAD} = \dot{Q}_{TOT}$$

$$\dot{Q}_{COND} = \frac{T_1 - T_2}{R_{COND}} \quad ; R_{COND} = \frac{L}{kA}$$

$$\dot{Q}_{CONV} = \frac{T_2 - T_\infty}{R_{CONV}} \quad ; R_{CONV} = \frac{L}{hA_s}$$

$$\dot{Q}_{RAD} = \frac{T_2 - T_{SURR}}{R_{RAD}} \quad ; R_{RAD} = \frac{1}{\varepsilon \sigma A (T_2 - T_{SURR})(T_2^2 - T_{SURR}^2)}$$

THE FIRST LAW OF THERMODYNAMICS

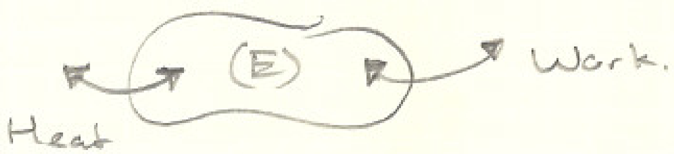
the first law of thermodynamics states

ENERGY CAN NEITHER BE CREATED NOR DESTROYED, ONLY TRANSFORMED.

this is referred to the conservation of energy

THE FIRST APPLIED LAW APPLIED TO A CLOSED SYSTEM

consider the closed system



the first law in differential form

$$dE = \delta Q - \delta W$$

where;

E: total energy

$E = U + KE + PE$.

$$\delta Q - \delta W = dU + dKE + dPE$$

Now when the process undergoes a process changing from initial state to a final state then integrating from 1-2 gives.

$${}_1Q_2 - {}_1W_2 = \Delta U + \Delta KE + \Delta PE$$

$\boxed{\text{* will not be provided for exam}}$

work done by the system on the surroundings during process 1-2

Heat transferred to the system during the process 1-2

note: $\Delta KE = \int_1^2 d(KE) = \int_1^2 d(\frac{1}{2}mv^2) = \frac{m(v_2 - v_1)}{2}$

$$= KE_2 - KE_1$$

$$\Delta PE = \int_1^2 d(PE) = \int_1^2 (mgz) = mg\Delta z$$

$$= mg(z_2 - z_1)$$

$\therefore$ we get.

$$\underbrace{{}_1Q_2 - {}_1W_2}_{\text{net energy transfer.}} = (U_2 - U_1) + \frac{1}{2}m(V_2^2 - V_1^2) + mg(z_2 - z_1)$$

REMARKS: The first law can be written in terms of m.

$$\frac{\delta Q}{m} - \frac{\delta W}{m} = \frac{dU}{m} + \frac{dKE}{m} + \frac{dPE}{m}$$

$${}_1q_2 - {}_1w_2 = \Delta e = \Delta u + \Delta ke + \Delta pe$$

$$= (u_2 - u_1) + \frac{1}{2}(V_2^2 - V_1^2) + g(z_2 - z_1)$$

REMARK: the first law can be written is terms of time

$$\dot{Q} - \dot{W} = \frac{dE}{dt} = \frac{dU}{dt} + \frac{dKE}{dt} + \frac{dPE}{dt}$$