Mech 262 : Thermodynamics 2
Assignment #3

Name: _______________ Date: Wedenesday may 21st completion marks only.

1. Determine the Heat Transfer in Watts for the following Wall section in an older style home (remember 2x4=1.5”x3.5”)
   Answer= 3.5W

2. Repeat the above question as if the air space with packed with

   a. Sawdust (7.3W)
   b. Fiberglass (4.5W)

-Notice that in this situation is seems that a hollow wall is actually better... however at this thickness, convection currents would come into play and the air gap can’t really be treated as a pure conductive element.

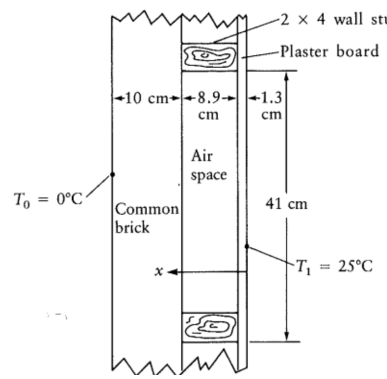


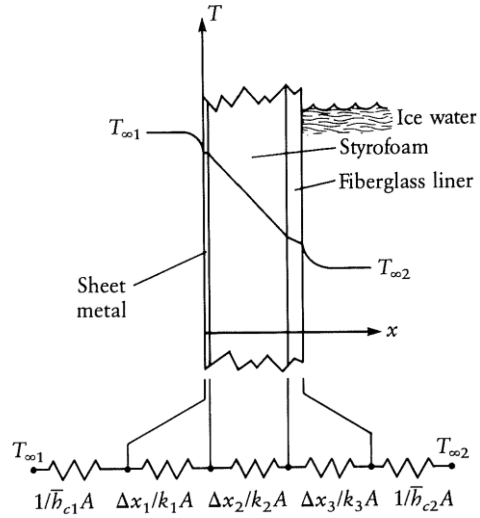
Table B.3 *Thermal properties of selected building materials and insulations at 293 K (20°C) or 528°R (68°F).*

Material	Specific gravity	Specific heat, c_p J/(kg·K)	Specific heat, c_p BTU/lbm·°R	Thermal conductivity, k W/(m·K)	Thermal conductivity, k BTU/hr·ft·°R	Diffusivity, α $m^2/s \times 10^5$	Diffusivity, α $ft^2/s \times 10^6$
Asbestos	0.383	816	0.195	0.113	0.0653	0.036	3.88
Asphalt	2.120			0.698	0.403		
Bakelite	1.270			0.233	0.135		
Brick							
Carborundum (50% SiC)	2.200			5.82	3.36		
Common	1.800	840	0.201	0.38–0.52	0.22–0.30	0.028–0.034	3.0–3.66
Magnesite (50% MgO)	2.000			2.68	1.55		
Masonry	1.700	837	0.200	0.658	0.38	0.046	5.0
Silica (95% SiO_2)	1.900			1.07	0.618		
Cardboard				0.14–0.35	0.08–0.2		
Cement (hard)				1.047	0.605		
Clay (48.7% moist)	1.545	880	0.210	1.26	0.728	0.101	10.9
Coal (anthracite)	1.370	1 260	0.301	0.238	0.137	0.013–0.015	1.4–1.6
Concrete (dry)	0.500	837	0.200	0.128	0.074	0.049	5.3
Cork board	0.150	1 880	0.449	0.042	0.0243	0.015–0.044	1.6–4.7
Cork (expanded)	0.120			0.036	0.0208		
Earth (diatomaceous)	0.466	879	0.210	0.126	0.072	0.031	3.3
Earth (clay with 28% moist)	1.500			1.51	0.872		
Earth (sandy with 8% moist)	1.500			1.05	0.607		
Glass fiber	0.220			0.035	0.02		
Glass (window pane)	2.800	800	0.191	0.81	0.47	0.034	3.66
Glass (wool)	0.200	670	0.160	0.040	0.023	0.028	3.0
Granite	2.750			3.0	1.73		
Ice at 0°C	0.913	1 830	0.437	2.22	1.28	0.124	13.3
Kapok	0.025			0.035	0.02		
Linoleum	0.535			0.081	0.047		
Mica	2.900			0.523	0.302		
Pine bark	0.342			0.080	0.046		
Plaster	1.800			0.814	0.47		
Plexiglas	1.180			0.195	0.113		
Plywood	0.590			0.109	0.063		
Polystyrene	1.050			0.157	0.0907		
Rubber							
Buna	1.250			0.465	0.269		
Ebonite	1.150	2 009	0.480	0.163	0.0942	0.006 2	0.67
Spongy	0.224			0.055	0.0318		
Sand							
Dry	1.640			0.582	0.336		
Moist				1.13	0.653		
Sawdust	0.215			0.071	0.041		
Wood							
Fir, pine, and spruce	0.444	2 720	0.650	0.15	0.087	0.012 4	1.33
Oak	0.705	2 390	0.571	0.19	0.11	0.011 3	1.22
Celotex	0.400			0.055	0.0318		
Fiber sheets	0.200			0.047	0.0172		
Wool	0.200			0.038	0.0220		

Notes: Density = ρ = specific gravity × 62.4 lbm/ft^3 = specific gravity × 1 000 kg/m^3
Diffusivity = α; for asbestos, $\alpha \times 10^5 = 0.036\ m^2/s$; so $\alpha = 0.036 \times 10^{-5}\ m^2/s$
Also, $\alpha = k/\rho c_p$

3. An Ice chest contains a mixture of ice and water at 32^0F. The shell is made from 0.040″ sheet steel (k=24.8 BTU/hr-ft-^{0}R), ¾″ Styrofoam (0.020 BTU/hr-ft-^{0}R), and ¼″ fibreglass (0.090 BTU/hr-ft-^{0}R). The outside air is 90^0F, and the combined convection/radiation coefficient is 0.79 BTU/hr-ft^2-^{0}R. The inside convection coefficient is 150 BTU/hr-ft^2-^{0}R.

   Calculate the heat transfer from the air to the ice **AND** the outside surface temp of the chest. (*Answer: 12.5Btu/hr, 74.3^{0}F*)



4. The bottom of a pan is made of a 5 mm thick aluminium layer. In order to increase the rate of heat transfer through the bottom of the pan someone proposes a design for the bottom which consists of a 3 mm thick copper layer sandwiched between two 2 mm thick aluminium layers. See the diagram below.
   a. Will the new design conduct heat better?
   (Explain you answer by determining the Thermal Resistance of the pan's bottom.)
   Assume perfect contact between the layers.
   b. What original thickness of the pan would be improved by the new design?
   (*Answer = 5mm<t<6mm*)

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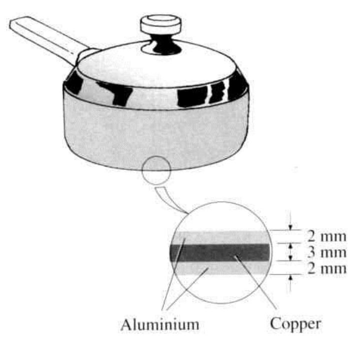

Go to www.goodfellow.com
"Index of Materials"
For Thermal Conductivity of materials:
Aluminum (Al)
Copper (Cu)

5. The silicon chip shown has an electrical power input of 0.225W. The top surface of the chip is exposed to a coolant whose temperature is 20^0C. The heat transfer coefficient for convection between the chip and the coolant is 150W/m2·K. If heat transfer by conduction between the chip and the substrate is negligible, determine the surface temperature of the chip, in ^{0}C. Include Radiation with an emissivity of ε=0.9.
   - State what % of heat is being removed via convection vs radiation *Answer=(96% cov, 4%rad)*
   - Notice that the unknown Surface Temp is *required* for the radiation component… therefor iteration will be needed to solve.