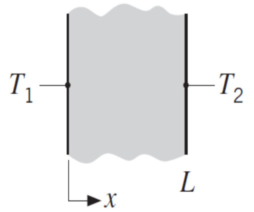
Tutorial Two

| *Introduction to conduction*|

Exercise 2.1 Fourier's Law

Consider steady-state conditions for one-dimensional conduction in a plane wall having a thermal conductivity **k = 50 W/m.K** and a thickness **L = 0.35 m**, with no internal heat generation.

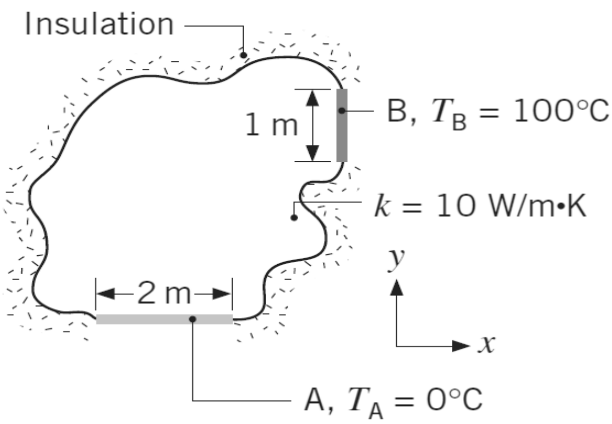


Determine the heat flux and the unknown quantity for each case and sketch the temperature distribution, indicating the direction of the heat flux.

Case	T_1(°C)	T_2(°C)	dT/dx (K/m)
1	50	-20	
2	-30	-10	
3	70		160
4		40	-80
5		30	200

Exercise 2.2

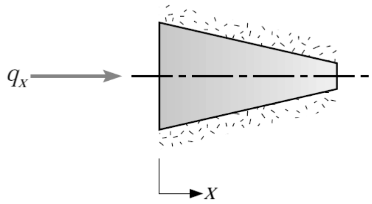
In the two-dimensional body illustrated, the gradient at surface **A** is found to be **∂T/∂y = 30 K/m**. What are **∂T/∂y** and **∂T/∂x** at surface **B**?



For the case where the thermal conductivity varies with temperature as $\mathbf{k = k_0 + aT}$, where $\mathbf{k_0 = 10}$ **W/m.K**, $\mathbf{a = -10^{-3}}$ $\mathbf{W/m.K^2}$, and T is in kelvins. The gradient at surface **B** is **∂T/∂x = 30 K/m**. What is **∂T/∂y** at surface **A**?

Exercise 2.3

Assume steady-state, one-dimensional heat conduction through the symmetric shape shown.



Assuming that there is no internal heat generation, derive an expression for the thermal conductivity **k(x)** for these conditions: **A(x) = (1 - x)**, **T(x) = 300(1 - 2x - x^3)**, and **q = 6000 W**, where **A** is in square meters, **T** in kelvins, and **x** in meters.

Exercise 2.4 Thermophysical Properties

Consider a **300 mm x 300 mm** window in an aircraft. For a temperature difference of **80 °C** from the inner to the outer surface of the window, calculate the heat loss through **L = 10-mm-thick** polycarbonate, soda lime glass, and aerogel windows, respectively.

Material	Thermal conductivity	unit
Polycarbonate (k_{pc})	**0,21**	
Soda lime glass (k_{slg})	**1,4**	(W/m.K)
Aerogel (k_{ag})	**0,014**	

If the aircraft has **130 windows** and the cost to heat the cabin air is **£1/kW.h**, compare the costs associated with the heat loss through the windows for an **8-hour** intercontinental flight.

Exercise 2.5

Test your understanding of various concepts by addressing the following questions:

1- An important property of matter is defined by *Fourier's law*. What is it? What is its physical significance? What are its units?
2- What is an *isotropic* material?
3- Why is the thermal conductivity of a solid generally larger than that of a liquid? Why is the thermal conductivity of a liquid larger than that of a gas?