Practical 1: Modes of Heat Transfer

Complete Q1-5 during the practical.

Ensure that you attempt Q3 before the next lecture.

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1. **Modes of Heat Transfer:** Engineers need to be able to consider real-life situations, identify the key processes occurring and describe these mathematically in a manner which allows questions to be answered quantitatively. For each of the situations below:
   - Draw a diagram identifying the transfers of heat
   - Is the heat transfer occurring at steady state, or is it unsteady?
   - Define the modes of heat transfer operating
   - Which mode do you think will be dominant? Why?
   - If convection is present, is it natural, forced, boiling or condensing?

   Situations:

   a) Liquid pitch (30°C) is pumped through an insulated pipeline in a New Zealand smelter, where air temperature is 5°C and wind speed is 20 kph.

   b) An electri

   c) A Brisban gated iron roof. It is midday,

   d) A motorbi hour journey). The engine is cooled by air passing over the e

   e) Cooling water from a power station (25°C (22°C).

   f) An operator in a casting house opens a f ences the heat given off by molten metal at 800°C.

   g) An esky is packed with food, beer and ice for a camping trip, then left in the sun

2. One side of a brick wall is at 40°C, the other side is at 20°C. The wall is 20cm thick. What is the rate of heat transfer through the wall? Thermal conductivity of brick is 0.72 $Wm^{-1}K^{-1}$.

3. An aluminium and copper block are clamped together. The cross-section of the blocks is 200cm by 200cm. Both plates are 10cm thick. Heat is being transferred through the plates, from the outside of the copper, across the interface and through the aluminium at a rate of 1MW. The outside (hottest) face of the copper block is at 500°C.
   a) What is the temperature at the interface between the copper and aluminum?
   b) What is the temperature on the outside face of the aluminium?

(Thermal conductivity of copper & aluminium are approximately 380 and 230 $WK^{-1}m^{-1}$ respectively in the range 0-500°C)

4. A rectangular black barbeque (BBQ) plate has dimensions 40 cm by 60 cm. In Brisbane, air at 25°C blows over the BBQ, and the convective heat transfer coefficient is 12 $Wm^{-2}K^{-1}$. If the BBQ plate is maintained at 250°C,

- **a)** What is the rate of heat loss from the plate due to convection?
- **b)** What is the rate of heat loss from the plate due to radiation?
- **c)** Assuming that all energy input is lost as convection and radiation from the surface of the plate, what power required to keep the BBQ plate at 250°C?

5. Consider the same BBQ plate from Q4, in Canberra on a windy day. The air temperature is 10°C and above the BBQ plate h=30 $Wm^{-2}K^{-1}$.

- **a)** Assuming the same rate of energy input to the BBQ, as calculated above, determine the steady state temperature of the BBQ plate in Canberra on a windy day [note: you may need to use a computer to solve]
- **b)** Calculate the rate of heat loss due to convection and radiation under these conditions. Compare to the Brisbane BBQ. How will this effect cooking on the BBQ in the two different cities?