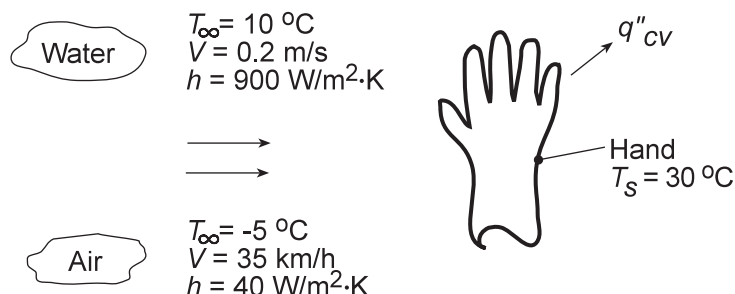


## PROBLEM 1.18

**KNOWN:** Hand experiencing convection heat transfer with moving air and water.

**FIND:** Determine which condition feels colder. Contrast these results with a heat loss of  $30 \text{ W/m}^2$  under normal room conditions.

**SCHEMATIC:**



**ASSUMPTIONS:** (1) Temperature is uniform over the hand's surface, (2) Convection coefficient is uniform over the hand, and (3) Negligible radiation exchange between hand and surroundings in the case of air flow.

**ANALYSIS:** The hand will feel colder for the condition which results in the larger heat loss. The heat loss can be determined from Newton's law of cooling, Eq. 1.3a, written as

$$q'' = h(T_s - T_{\infty})$$

For the air stream:

$$q''_{\text{air}} = 40 \text{ W/m}^2 \cdot \text{K} [30 - (-5)] \text{ K} = 1,400 \text{ W/m}^2 \quad <$$

For the water stream:

$$q''_{\text{water}} = 900 \text{ W/m}^2 \cdot \text{K} (30 - 10) \text{ K} = 18,000 \text{ W/m}^2 \quad <$$

**COMMENTS:** The heat loss for the hand in the water stream is an order of magnitude larger than when in the air stream for the given temperature and convection coefficient conditions. In contrast, the heat loss in a normal room environment is only  $30 \text{ W/m}^2$  which is a factor of 400 times less than the loss in the air stream. In the room environment, the hand would feel comfortable; in the air and water streams, as you probably know from experience, the hand would feel uncomfortably cold since the heat loss is excessively high.