MEBS6006 Environmental Services I

http://www.hku.hk/mech/msc-courses/MEBS6006/index.html

Exercises on Thermal Comfort

1. Which mechanism in thermal comfort study is each of the following referring to?

Solution:

- A warm body transferring heat across space to surrounding surface. ➔ Radiation

- The heat flow through a substance by physical contact. ➔ Conduction

- Cooler air warmed by the body rise, drawing in more cool air to the body. ➔ Convection

- Moisture exits the body through pores in the skin and changes to a vapour causing the skin to cool. ➔ Evaporation

2. What are the two important conditions for achieving thermal comfort?

Solution:

(1) Heat produced must equal heat lost, and
(2) Signals from Heat- and Cold-sensors must neutralise each other

3. Briefly describe the heat balance equation for assessing thermal comfort and its parameters.

Solution:

The heat balance equation for thermal comfort is:

$$\mathbf{S = M - W - E - (R + C)}$$

- S = Rate of heat storage; proportional to rate of change in mean body temp.; normally, S is zero; adjusted by the thermo-regulatory system of the body
- M = Metabolic rate; heat released from human body per unit skin area, depends on muscular activities, environment, body sizes, etc.; 1 met = 58.2 W/m^2 (seated quiet person)
- W = Mechanical work, energy in human body transformed into external mechanical work
- E = Evaporative heat loss; release of latent heat energy from evaporation of body fluid respired vapour loss; E_{res} (respiration heat losses: latent E_{rel} and sensible E_{rec}) and evaporative heat loss from skin E_{sk} (include skin diffusion E_{dif} and regulatory sweating E_{rsw})
- R + C = Dry heat exchange, through convective and radiative heat transfer; heat loss by radiation if skin temp. > temp. of surrounding surfaces; heat loss by convection if skin temp. > dry bulb temp.

4. Explain the meaning of the following environmental indices used for evaluating the perception of thermal comfort.

   i) Mean radiant temperature
   ii) Operative temperature
   iii) Effective temperature
   iv) Equivalent temperature

Solution:

i) Mean radiant temperature = uniform temp. of an imaginary black enclosure which result in the same heat loss by radiation as the actual enclosure

ii) Operative temperature = uniform temp. of an imaginary enclosure with the same dry heat by R + C as in the actual environment (integrate dry-bulb and MRT)

iii) Effective temperature = temp of an environment at 50%RH that results in the same total heat loss from the skin as for the actual environment (combine temp. & humidity effect)

iv) Equivalent temperature = temp. that integrates the effect of dry-bulb, MRT and air velocity, also called wind-chill temperature

5. Briefly explain the four situations where local thermal discomfort may happen.

Solution:

Four situations of local thermal discomfort:

- Draught (excessive air velocity, high turbulence)
- Radiation asymmetry (e.g. warm ceilings and cold walls)
- Vertical air temperature gradient (e.g. difference between air temperature at ankle and neck level)
- Floor temperature (e.g. cold floor in bathroom)