submission week **4**

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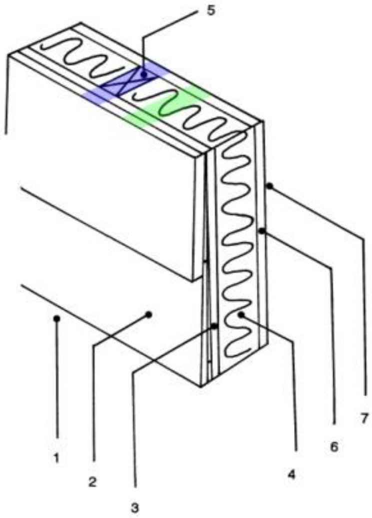
1 Determine the overall unit thermal resistance (the *R*-value) and the overall heat transfer coefficient (the *U*-factor) of a wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13 mm playwood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% of the heat transmission area while the studs, plates, and sills constitute 21%. The headers constitute 4% of the area, and they can be treated as studs (this means 75% of area is insulation and 25% can be considered wood).
Also, determine the rate of heat loss through the walls of a house whose perimeter is 50 m and wall height is 2.5 m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing.



layer	material	section A	section B
1	outside surface	0.03	0.03
2	wood bevel lapped siding (13mm*200mm)	0.14	0.14
3	Playwood (13mm)	0.11	0.11
4	urethane rigid foam (90mm)	-	0.98*90/25 = 3.528
5	wood stud (90mm)	0.63	-
6	gypsum wallboard (13mm)	0.079	0.079
7	inside surface	0.12	0.12

section A: section with wood
section B: section with insulation

$$R'_{Wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109\ m^2.°C/W$$

$$R'_{Ins} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007\ m^2.°C/W$$

$$U_{Wood} = \frac{1}{R'_{wood}} = \frac{1}{1.109} = 0.9017\ \frac{W}{m^2°C}$$

$$U_{Ins} = \frac{1}{R'_{Ins}} = \frac{1}{4.007} = 0.2495\ \frac{W}{m^2°C}$$

$$A_{wall} = 50 * 2.5 * 0.8 = 100\ m^2$$

$$U_{tot} = U_{wood} \times \frac{A_{wood}}{A_{tot}} + U_{ins} \times \frac{A_{ins}}{A_{tot}}$$

$$U_{tot} = U_{Wood} \times 0.25 + U_{Ins} \times 0.75 = 0.9017 * 0.25 + 0.2495 * 0.75 = 0.4125\ \frac{W}{m^2°C}$$

$$\Delta T = 22 - (-2) = 24°C$$

$$Q_{tot} = U_{tot} \times A_{tot} \times \Delta T = 0.4125 * 100 * 24 = 990\ W$$

2 In 2 pages write a summary of what you have learnt in the session about radiation and radiative heat transfer.

Radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium.

This phenomenon occurs when a hot object even in a vacuum chamber loses heat and reaches thermal equilibrium with its surroundings.

Radiation transfer does not require the presence of a material medium to take place (unlike conduction and convection) and it can occur in solids, in liquids or in gases.

Radiation includes **electromagnetic radiation** which refers to the waves of the electromagnetic fields propagating through space carrying electromagnetic radiant energy as a result of the changes in the electronic configurations of the atoms or molecules.

Electromagnetic waves are characterized by their frequency (ν) or wavelength (c). These two properties in a medium are related by the speed of propagation of a wave in that medium (λ).

$$\lambda = c/\nu$$

Electromagnetic radiation is the propagation of elementary particle called photons. The energy of a photon is inversely proportional to its wavelength.

THERMAL RADIATION

- Thermal radiation is electromagnetic radiation generated by the thermal motion of particles in matter.
- All matter with a temperature greater than absolute zero emits thermal radiation.
- The rate of thermal radiation emission increases with increasing temperature.

LIGHT

- Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum (between 0.40 and 0.76 μm) that is visible by the human eye.
- A body that emits visible radiation is called light source.
- Ultraviolet radiation has a shorter wavelength than visible light (between 0.01 and 0.40 μm).
- Infrared radiation has a longer wavelenght than visible light (between 0.76 and 100 μm).

BLACK BODY RADIATION

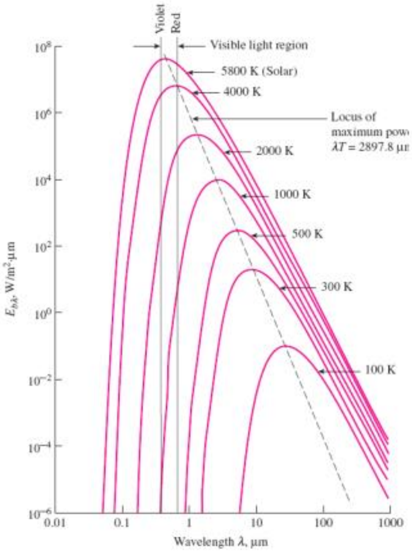
- Black body radiation is the thermal electromagnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment.
- A black body is an idealized body considered as a standard that can be compared with the radiative properties of real surfaces (in nature there are no perfect black bodies).
- It is an object that absorbs all radiation falling on it, at all wavelengths and in all direction.
- A blackbody emits the maximum amount of radiation by a surface at a given temperature.
- In nature bodies emit different amounts of radiation per unit surface area

The radiation energy emitted by a blackbody is espressed by:

$$E_b(T) = \sigma\, T^4 \qquad (W/m^2)$$

The **spectral blackbody emissive power** is the amount of radiation energy emitted by a blackbody at a thermodynamic temperature T per unit time, per unit surface area, and per unit wavelength about the wavelength λ and it is espressed by Planck's law.

A perfectly insulated enclosure that is in thermal equilibrium internally will emit black-body radiation through a hole in its wall, provided that the hole is small enough to have a negligible effect on the internal balance.



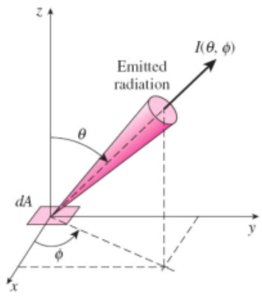
THE VARIATION OF THE BLACK BODY EMISSIVE POWER WITH WAVELENGHT FOR SEVERAL TEMPERATURES

OBSERVATION

- The emitted radiation is a function of wavelength (at any temperature it increases with wavelength, reaches a peak and then decreases with increasing wavelength).
- The emitted radiation increases with increasing temperature (at any wavelength).
- A larger fraction of the radiation is emitted at shorter wavelengths at higher temperatures.
- The radiation emitted by the sun (considered as a blackbody at 5800 K) reaches its peak in the visible liht region. For this reason we can see it.
- Surfaces at T < 800 K emit almost entirely in the infrared region and thus are not visible to the uman eye unless they reflect light coming from other sources.

RADIATION INTENSITY

- Radiation intensity is the radiant flux emitted, reflected, transmitted or received, per unit solid angle in a specified direction in space (it is a directional quantity). It is denoted by I.
- Radiation is emitted by all parts of a plane surface in all directions into the region above the surface.
- The directional distribution of radiation is usually not uniform.



EMISSIVE POWER

- The region above the surface intercept all the radiation rays emitted by the surface.
- The emissive power is the power emitted from the surface into the surrounding.
- The intensity of radiation emitted by a surface varies with direction.
- Many surfaces in practice can be considered as diffuse emitting surface, in this case the intensity of the emitted radiation is independent of direction and thus the emissivity is constant.

INCIDENT RADIATION

- All surfaces emit and receive radiation to and by other surfaces.
- Incident radiation is defined as the rate at which the radiation energy (dG) is incident from a specific direction, per unit area of the receiving surface, normal to this direction and per unit of solid angle around this direction.
- The radiation flow incident on a surface from all directions is called irradiation G.

RADIOSITY

- The calculation of radiation heat transfer between surfaces involves the total radiation energy (emitted and reflected).
- Radiosity (J) is the quantity that represents the rate at which radiation energy leaves a unit area of a surface in all directions.