*weekly_submission_**04***

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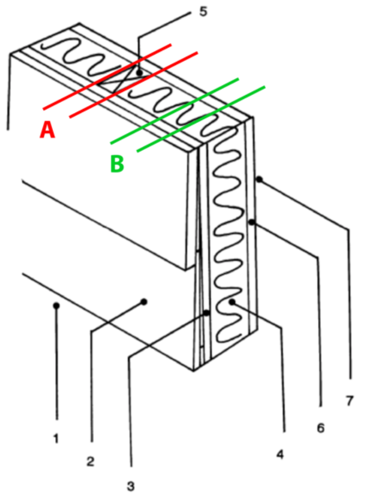
> Determine the overall unit thermal resistance (the R-value) and the overall heat transfer coefficient (the U-value) of a wood frame wall that is built around $38\ mm$ $90\ mm$ wood studs with a center-to-center distance of $400\ mm$. The $90\ mm$ wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finished with $13\ mm$ gypsum wallboard and the outside with $13\ mm$ plywood 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% of the wall area is occupied by glazing.



	Section A	Section B
1. Outside surface	0,03	0,03
2. Wood Bevel Lapped Siding ($13mm * 200mm$)	0,14	0,14
3. Plywood ($13mm$)	0,11	0,11
4. Urethane Rigid Foam Insulation ($90mm$)	---	$\frac{0{,}98 * 90}{25} = 3{,}528$
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

The area of the wall:

$$A = 50 * 2{,}5 * 0{,}8 = 100\ m^2$$

The temperature variation:

$$\Delta T = 22 - (-2) = 24°C$$

The overall unit thermal resistance:

$$R'_{with\_wood} = (0{,}03 + 0{,}14 + 0{,}11 + 0{,}63 + 0{,}079 + 0{,}12)\frac{m^2°C}{W} = 1{,}109\frac{m^2°C}{W}$$

$$R'_{with\_insulation} = (0{,}03 + 0{,}14 + 0{,}11 + 3{,}528 + 0{,}079 + 0{,}12)\frac{m^2°C}{W} = 4{,}007\frac{m^2°C}{W}$$

The overall heat transfer coefficient:

$$U_{tot} = U_{wood} * \frac{A_{wood}}{A_{tot}} + U_{insulation} * \frac{A_{insulation}}{A_{tot}} = U_{wood} * 0{,}25 + U_{insulation} * 0{,}75$$

$$U_{wood} = \frac{1}{R'_{with\_wood}} = \frac{1}{1{,}109} = 0{,}9017\ \frac{W}{m^2°C}$$

$$U_{insulation} = \frac{1}{R'_{with\_insulation}} = \frac{1}{4{,}007} = 0{,}2496\ \frac{W}{m^2°C}$$

$$U_{tot} = 0{,}9017 * 0{,}25 + 0{,}2496 * 0{,}75 = 0{,}226 + 0{,}188 = 0{,}4126\ \frac{W}{m^2°C}$$

The rate of heat loss through the wall:

$$Q_{tot} = U_{tot} * A_{tot} * \Delta T = 0{,}4126 * 100 * 24 = 990{,}24\ W$$

> Summary about radiation and radiative heat transfer

Radiation is, in general, the emission of energy in form of waves or particles through the space.
The third type of heat transfer is radiation and it is significantly different from conduction and convection because it does not require the presence of a material medium to take place.
Radiation transfer occurs in solid as well as liquid and gases.

Not all the waves are related to heat transfer, only thermal radiation emitted as a result of energy transitions of molecules, atoms, and electrons of a substance.

Thermal radiation is the emission of electromagnetic waves from all matter that has a temperature greater than absolute zero (0 K or -273,15°C), it is due to the heat of the material, the characteristics of which depend on its temperature.

<u>ELECTROMAGNETIC WAVES</u>

Electromagnetic waves are characterized by their frequency ν and the wavelength λ, related in this way:

$\lambda = \frac{c}{\nu}$ where $c = \frac{c_0}{n}$

c = the speed of propagation of wave in that medium

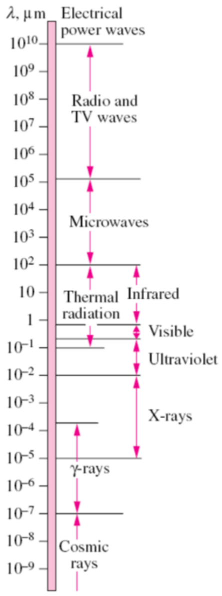
$c_0 = 2{,}9979 \cdot 10^8\ {}^{m}/_{s}$, the speed of ligh in a vacuum

$n =$ the index of refraction of that medium

It means that wavelength and frequency are inversely proportional: the lower the frequency, the higher the wavelength and vice versa.

Each proton of frequency n composing electromagnetic radiation, is considered to have and energy of:

$e = h\nu = \frac{hc}{\lambda}$ also in this case, the energy of a photon is inversely proportional to its wavelength.



An important example of radiation is the sun, which emits heat though radiation.

Other forms of radiation which comes in waves includes radio waves, visible light which we can see as colors in everyday life, microwaves ,ultraviolet, x-rays…

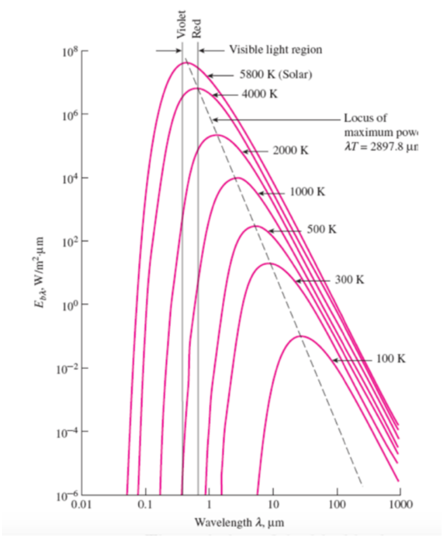
<u>BLACK BODY</u>

The thermal radiation is continually emitted from every part of the surface of the object that has a temperature greater than absolute zero into every direction.
Surface emit thermal radiation and reflect electromagnetic waves at the same times.

We can use an idealized body called “black body” (that doesn’t exist in the real life), that emits radiation but does not reflect any electromagnetic waves. The black body emits the maximum amount of radiation by a surface at a given temperature and absorbs all incident radiation, regardless of wavelength and direction.

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 could be express in this way, with the Plank’s law:

$$E_{b\lambda}(\lambda, T) = \frac{C_1}{\lambda^5[\exp(C_2/\lambda T) - 1]}$$



This graphic shows the variation of the black body emissive power with wavelength for several temperature. From this we can understand that the emitted radiation is a continuous function of wavelength. At any specified temperature, it increases with wavelength, reaches a peak, and then decreases with increasing wavelength.

At any wavelength, the amount of emitted radiation increases with increasing temperature.

RADIATION INTENSITY (*I*) AND EMISSIVE POWER (*E*)

It's a quantity that describe the magnitude of radiation emitted (or incident) in a specific direction in space. This is because the radiation is emitted from all parts of a flat surface in all directions in the hemisphere above the surface and the directional distribution of the emitted radiation (or incident) is usually not uniform.
For a diffusely emitting surface, the intensity of the emitted radiation is independent of direction and thus the emissivity is constant:

$$E = \pi I_e$$

IRRADIATION (*G*)

All surfaces emit radiation, but they also receive radiation emitted or reflected by other surfaces. The radiation flux incident on a surface from all directions is called irradiation:

$$G = \pi I_i$$

RADIOSITY (*J*)

It's the quantity that represents the rate at which radiation energy leaves a unit area of a surface in all directions. This quantity is express by:

$$J = \pi I_{e+i}$$