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1. A wood frame wall that is built around 38mm-90mm wood studs with a centre to centre distance of 400mm. The 90mm wide cavity between the studs is filled with the urethane rigid foam insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13mm plywood and 13-20mm wood bevel lapped siding. The insulated cavity constitutes 75 percent of the heat transmission area while the studs, plates, and sills constitute 21 percent. The header constitute 4 percent of the area and they can be treated as studs (this means 75% of area is insulation and 25% can be considered wood.)

Find the R unit values, determine the overall unit thermal resistance (the R value) and the overall heat transfer coefficient (the U-factor)

Answer:

	Wood	**Insulation**
Outside Air	0.03	0.03
Wood Bevel (13mm*200mm)	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane Rigid foam Ins (90mm)	No	9=0.98*(90/25)=3.528
Wood studs (90mm)	0.63	No
Gypsum Board (13mm)	0.079	0.079
Inside Surface	0.12	0.12

$R'_{\text{with wood}} = 0.03+0.14+0.11+0.63+0.079+0.12\ m^2\ \frac{°C}{W} = 1.109\ m^2\ \frac{°C}{W}$

$R'_{\text{with insulation}} = 0.03+0.14+0.11+3.528+0.079+0.12\ m^2\ \frac{°C}{W} = 4.007\ m^2\ \frac{°C}{W}$

$U_{\text{wood}} = \frac{1}{R'\text{with wood}} = \frac{1}{1.109} = 0.9017\ \frac{W}{m2\ °C}$

$U_{\text{insulation}} = \frac{1}{R'\text{with wood}} = \frac{1}{4.007} = 0.2496\ \frac{W}{m2\ °C}$

$\frac{1}{R'\text{total}} = \frac{1}{R'\text{wood}} + \frac{1}{R'\text{insulation}}$

$R' = R * A,\qquad R = \frac{R'}{A}\qquad \text{Hence,}\qquad \frac{1}{R} = \frac{A}{R'}$

$$\frac{1}{\frac{R'\text{total}}{A\text{ total}}} = \frac{1}{\frac{R'\text{wood}}{A\text{ wood}}} + \frac{1}{\frac{R'\text{insulation}}{A\text{ insulation}}}$$

$$\frac{A\text{ total}}{R'\text{total}} = \frac{A\text{ wood}}{R'\text{wood}} + \frac{A\text{ insulation}}{R'\text{insulation}}$$

$\frac{1}{R'} = U$,

$A_{total} * U_{total} = A_{wood} * U_{wood} + A_{insulation} * U_{insulation}$

$U_{total} = \frac{A\ wood}{A\ total} * U_{wood} + \frac{A\ insult}{A\ total} * U_{insulation}$

$= (21\% + 4\%)\ U_{wood} + 75\ \% * U_{insulation}$

$= 25\% * 0.9017 + 75*0.2496 = 18.9454\ 0.4126\ \frac{W}{m2\ ℃}$

The overall thermal resistance

$R_{value} = \frac{1}{U\ total} = \frac{1}{0.4126} = 2.4237\ \frac{m2\ ℃}{W}$

The rate of heat loss through the walls

Q total = U total * A total * **Δ** T

=0.4126 * 50* 2.5* (1-20) * 22-(-2) =990.24 W

2. Summary about radiation and radiative heat transfer

Radiation, is the transmission of energy by electromagnetic waves. It is the energy that transfers from one space to the other where there are different surrounding conditions with no thermal equilibrium. Typical examples of radiation are light and heat.

Radiation is independent of conduction and convection because it does not require material medium to perform action. That is why we are able to receive and feel heat emitted by sun inspite of vacuum being not the state of matter for energy transfer. Radiation heat transfer can also occur in solids, liquids and gasses.

A particular type of radiation is constituted by electromagnetic waves, they represent the energy emitted by matter as a result of the changes in configuration of the molecules.

Object emit radiation when high energy electrons in a higher atomic level fall down to lower energy levels. The energy lost is emitted as light or electromagnetic radiation. All objects absorb and emit radiation.

When the absorption of the energy balances the emission of the energy, temperature of the object remains constant. If the absorption of the energy is greater than the emission of the energy, temperature of the object rises. If the absorption of the energy is less than the emission of the energy, the temperature of an object decreases.

Radiations can be Natural or Man-made. Our body is exposed to natural radiation in our day to day life, such as soil, underground gasses, sun, etc. Man-made radiation exposure our body such as radio, television, cell phones, microwaves and radiations from medical and nuclear experiments. It is dangerous to our body but it depends on the strength, type and the length of exposure.

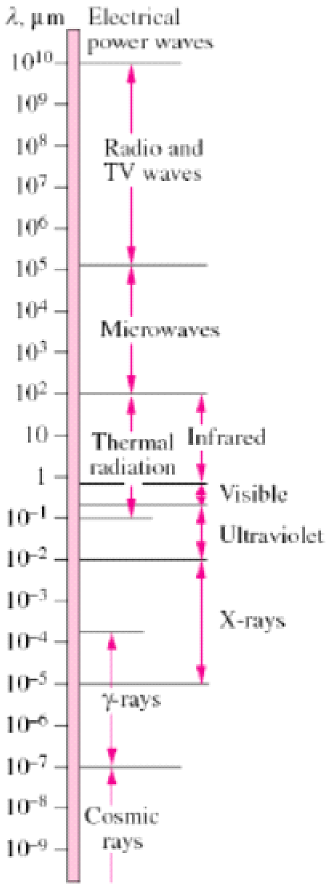
Humans cannot see the ultra-violet UV rays and this is the reason our skin is burned because of sun. Exposure to these rays are harmful for the body and hence the exposure must be avoided.

TABLE 12–1

The wavelength ranges of different colors

Color	Wavelength band
Violet	0.40–0.44 μm
Blue	0.44–0.49 μm
Green	0.49–0.54 μm
Yellow	0.54–0.60 μm
Orange	0.60–0.67 μm
Red	0.63–0.76 μm

A medium that emits radiation that can be visible is called light source. Sun is our primary source of light, Radiation emitted from sun are called Solar Radiations. Solar radiation consists of light (visible), ultra-violet light (in-visible) and infra-red light (in-visible).



The electromagnetic wave spectrum.

Black Body:

Bodies that radiate energy into the environment are the constantly receiving energy from the environment. It is the ideal body that emits the maximum amount of radiation. It is perfect emitter and absorber of all the incident radiation.

If the body and its environment are at the same temperature, them the energy emitted is equal to the energy absorbed. The body and environment are in a state of dynamic equilibrium.

Different bodies produce different amount of radiation. Bodies that are good in heat emission are also good in absorption of radiation.