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 plywood and 13-mm 200-mm 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 headers constitute 4 percent of the area, and they can be treated as studs. 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.

	Wood	Insulation
Outside air	0.03	0.03
Wood stud - 90mm	0.63	NO
Urethane rigid foam insulation-90 mm	NO	$0.98 * \frac{90}{25}$ $= 3.528$
Gypsum wallboard- 13 mm	0.079	0.079
Plywood- 13mm	0.11	0.11
Wood bevel- 13*200mm	0.14	0.14
Inside surface	0.12	0.12

$R'_{withwood}$ = 0.03 + 0.63 + 0.079 + 0.11 + 0.14 + 0.12 = 1.109 $m^2 \cdot \frac{W}{C}$

$R'_{withinsulation}$ = 0.03 + 3.528 + 0.079 + 0.11 + 0.14 + 0.12 = 4.007 $m^2 \cdot \frac{W}{C}$

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

$$U_{insulation} = \frac{1}{R'_{withinsulation}} = \frac{1}{4.007} = 0.2496 \ \frac{W}{m^2 \cdot C}$$

$$\therefore \frac{1}{R_{total}} = \frac{1}{R_{wood}} + \frac{1}{R_{insulation}} \qquad But, R = \frac{R'}{A} \ \therefore \frac{1}{R} = \frac{A}{R'}$$

$\therefore \frac{A_{total}}{R_{total}} = \frac{A_{wood}}{R'_{wood}} + \frac{A_{insulation}}{R'_{insulation}}$

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

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

Both equation divided by A_{total}

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

$= 0.4126 \frac{W}{m^{2\circ}C}$

R = $\frac{1}{U_{total}} = \frac{1}{0.4126} = 2.4237 \frac{W}{m^{2\circ}C}$

And , $\dot{Q} = U_{total} * A_{total} * \Delta T = 0.4126 * 50 * 2.5 * 91 - 20)\% * (22+2) = 990.24\, W$

Summary about Radiation and Radioactive heat transfer

Thermal radiation is an incident caused by the increase of temperature of an object. Radiation is basically electromagnetic waves radiated from an object as heat changes from absolute zero. When any object gains heat through convection and conduction, it's temperature increases to a significant rate and it's molecules and atoms releases energy which is characterized as thermal radiation. But it does not need any medium to transfer radiation, unlike heat transfer. Eventually, all materials have their radiation. The higher the temperature, the more radio-active the particles become.

Radiation is released in form of waves in the environment. It can also occur in a vacuum space without medium. That is why, it can be measured by wavelength and frequency. The speed of the waves are very high and quite powerful. For an example, we see the sunshine every day, the light of sun comes to the earth and lights it because of radiation. The sun is a hot object and the temperature is really high, so it emits huge amount of radiation which comes to the world as sunlight but loses its harmful character in its way.

The radiation of any object can be calculated by the equation,

$$c = \lambda v$$

Where 'c' is the speed of light, 'λ' is the wavelength and 'v' is the velocity.

When an object emits radiation, all the surfaces of the element radiates electromagnetic waves which is invisible to the human eye. All object has radioactive quality which is usual. But at a greater extent, it can be harmful for humans. The worst effect of radioactivity to life can be seen in the Chernobyl nuclear power plant explosion incident where the amount of radiation was extremely harmful for any kind of life in the world. After a nuclear reactor core exploded due to overheat, a large amount of energy was suddenly

released. It spreaded radioactive contamination invisible to the eye which polluted every organic life of surrounding area instantly. So, the radioactivity of material can only be harmful when it crosses a significant limit.

All radiation incident has some qualities like emission, absorption and reflection. So, it also reflects in contact of particular material. And the absorption happens too, here comes the theory of black body. A black body is considered as an element which completely absorbs radiation.