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 rigif foam. 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 (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.

	Wood	Insulation
Outside Air	0.03	0.03
Wood Bevel (13mm*200mm)	0.14	0.14
Polywood(13mm)	0.11	0.11
Urethane Rigif Foam Ins. (90mm)	No	3.528
Wood Studs(90mm)	0.63	No
Gypsum Borad(13mm)	0.079	0.079
Inside Surface	0.12	0.12

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

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

$$\because \frac{1}{R_{total}} = \frac{1}{R_{withwood}} + \frac{1}{R_{withinsulation}}$$

$$R'_{withwood} = R_{withwood} \cdot A_{withwood},\quad R'_{withinsulation} = R_{withinsulation} \cdot A_{withinsulation}$$

$$R'_{total} = R_{total} \cdot A_{total}$$

$$\therefore \frac{A_{total}}{R'_{total}} = \frac{A_{withwood}}{R'_{withwood}} + \frac{A_{withinsulation}}{R'_{withinsulation}}$$

$$\because U_{withwood} = \frac{1}{R'_{withwood}}, U_{withinsulation} = \frac{1}{R'_{withinsulation}}, U_{total} = \frac{1}{R'_{total}}$$

$$\therefore A_{total} \cdot U_{total} = A_{withwood} \cdot U_{withwood} + A_{withinsulation} \cdot U_{withinsulation}$$

Divide everything by A_{total}

$$\therefore U_{total} = \frac{A_{withwood}}{A_{total}} \cdot U_{withwood} + \frac{A_{withinsulation}}{A_{total}} \cdot U_{withinsulation}$$

$\therefore U_{total} = 25\% \cdot U_{withwood} + 75\% \cdot U_{withinsulation}$

$= 25\% \cdot \frac{1}{R'_{withwood}} + 75\% \cdot \frac{1}{R'_{withinsulation}} = 25\% \cdot \frac{1}{1.109 \frac{m^2\,℃}{W}} + 75\% \cdot \frac{1}{4.007 \frac{m^2\,℃}{W}}$

$= 0.4126 \frac{W}{m^2\,℃}$

$\mathrm{R-value} = \frac{1}{U_{total}} = \frac{1}{0.4126 \frac{W}{m^2\,℃}} = 2.4237 \frac{m^2\,℃}{W}$

From the definition of U

$\dot{Q}_{total} = U_{total} \cdot A_{total} \cdot \Delta T = 0.4126 \frac{W}{m^2\,℃} \cdot 50m \cdot 2.5m \cdot 80\% \cdot [22\,℃ - (-2\,℃)]$

$= 990.24W$

In 2 pages you shoudl write a summary (in your own word!, in your own words !!) of what you have learnt in this session about radiation and radiative heat transfer

Radiation, rather than conduction and convection, transfers heat energy by electromagnetic wave, which can spread in vacuum, meaning that radiative heat transfer could occur without touching, without any medium.

Radiation transfer occurs in solids as well as liquids and gases, any object around us with a temperature above absolute zero. It occurs due to energy transitions of molecules, atoms, and electrons of a substance.

The characteristic of radiative heat transfer is that the thermal energy of the emitter becomes electromagnetic wave radiant energy, and the irradiated body converts the received radiant energy into heat energy.

Temperature is a measure of the strength of these activities at the microscopic level. The higher the temperature, the stronger the heat radiation.

Any object not only has the ability to emit thermal radiation itself, but also absorbs and reflects external radiation. Some object (like glass and plastic film, etc.) can also transmit the radiation.

Electromagnetic waves transport energy just like other waves and they are characterized by their frequency (v) or wavelength (λ), and the relationship between can be described as λ=c/v.

$c = c_0/n$

c, the speed of propagation of a wave in that medium

$c_0 = 2.9979 * 10^8$, the speed of light in a vacuum

n, the index of refraction of that medium

The radiation with λ > 3μm is regarded as long wave radiation, while that with λ < 3μm is called short wave radiation, and with certain temperature, most radiant energy emitted from the surface of an object occurs with the λ range from 0.4μm to 7μm. (Like solar surface temperature is 6000K, respresenting about λ=0.483μm, a sort of short wave radiation.)

When an object is exposed to radiation (energy Q) from other objects, it produces three phenomena: absorption, reflection and penetration. If we regard the total energy as Q, then the relationship between these parts and the total energy as shown in the following equation:

$$Q=QA+QR+QD$$

if we regard A=QA/Q as absorption rate, R=QR/Q as reflection rate, D=QD/Q as penetration rate, A+R+D=1

if A=1, R=D=0, that is, the energy of thermal radiation reaching the surface of the object is completely absorbed, the object is called absolute black body, short for black body.

In fact, there is no absolute black body, only some objects are close to absolute black body.

A blackbody, an idealized body to serve as a standard against which the radiative properties of real surfaces may be compared, emits the maximum amount of radiation by a surface at a given temperature; absorbs all incident radiation, regardless of wavelength and direction.

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. As temperature increases, the curves shift to the left to the shorter wavelength region. Consequently, a larger fraction of the radiation is emitted at shorter wavelengths at higher temperatures.