Question1

Determine the overall unit thermal resistance(the R-value) and the overall heat transfer coefficient(the U-factor) of a wall frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400mm. The 90-mm-wide cavity between the studs is filled with urethane rigif foam. The inside is filled with 13-mm gypsum wallboard and outside with 13-mm plywoodand 13-mm and 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% heat transmission area while the studs, plates, and sills constitutes 21%. The headers constitutes 4% 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 50m and wall height is 2.5m in Las Vegas, Nevada, whose winter design temperature is -2 . Take the indoor design temperature to be 22 and assume 20% of the wall area is occupied by glazing.

	WOOD	INSULATION
Outside air	0.03	0.03
Wood bevel(13mm-200mm)	0.14	0.14
Plywood(13mm)	0.11	0.11
Urethane rigif foam(90mm)	NO	0.98/25*90=3.528
Wood studs(90mm)	0.63	NO
Gypsum board(13mm)	0.079	0.079
Inside surface	0.12	0.12

$R_{total,wood}$=0.03+0.14+0.11+0.63+0.079+0.12=1.109℃/W

$R_{total,ins}$=0.03+0.14+0.11+3.528+0.079+0.12=4.007℃/W

R'=Rtotal*Atotal

$1/R' = 1/R_{total,wood} + 1/R_{total,ins}$

$A_{total}/R' = A_{total,wood}/R_{total,wood} + A_{total,ins}/R_{total,ins}$

$U_{total} * A_{total} = U_{total,wood} * A_{total,wood} + U_{total,ins} * A_{total,ins}$

$$U_{total} = \frac{A_{total,wood}}{A_{total}} * U_{total,wood} + \frac{A_{total,ins}}{A_{total}} * U_{total,ins}$$

$=25\% U_{total,wood} + 75\% U_{total,ins}$

$$=25\%\frac{1}{R_{total,wood}} + 75\%\frac{1}{R_{total,ins}}$$

$=0.4126 W/m^2℃$

R-value=$1/U_{total}$=$2.4237 m^2℃/W$

$\dot{Q} = U_{total} * A_{total} * \Delta T = 990.24W$

Summary about radiation and radiative heat transfer

- **Definition of electromagnetic wave**

Electromagnetic waves are oscillating particle waves that are generated by the electric field and magnetic field in the same phase and perpendicular to each other. They are electromagnetic fields that propagate in the form of waves.

The process of relying on electromagnetic wave radiation to achieve heat transfer between hot and cold objects is a non-contact heat transfer that can also be carried out in a vacuum. The electromagnetic waves emitted by the object are theoretically distributed over the entire spectrum, but in the temperature range encountered in the industry, the practical significance is the thermal radiation with a wavelength between 0.38 and 1000, and most of them are located in the infrared (again It is called the heat ray) in the range of 0.76 to 20. The so-called infrared heating is to use the thermal radiation of this section.

$c=\lambda f$

c: wave speed (the speed of light is a constant, approximately equal to 3 × 10 ^ 8 m / s in vacuum)
Unit: m / s

f: frequency (unit: Hz, 1 MHz = 1000 kHz = 1 × 10 ^ 6 Hz)

λ: wavelength (unit: m)

The wave velocity of the electromagnetic wave in vacuum is c, which is equal to the product of the wavelength λ and the frequency f.

$c=\lambda f$

The speed of electromagnetic wave propagation in vacuum c - about 300,000 kilometers per second, is the fastest speed of material movement in the universe. c is a very important constant in physics. The currently accepted values are:

c=299792.458km/s≈3×10^×8m/s

Arranging these electromagnetic waves in order of wavelength or frequency is the electromagnetic spectrum. If the frequency of each band is arranged in order from low to high, they are power frequency electromagnetic waves, radio waves (divided into long wave, medium wave, short wave, microwave), infrared rays, visible light, ultraviolet rays, X rays, and gamma rays. The longest wavelength of the radio, the shortest wavelength of cosmic rays (x-rays, gamma rays, and shorter wavelengths)

- **Definition of thermal radiation**

Thermal radiation, the phenomenon in which an object radiates electromagnetic waves due to its temperature. One of the three ways of heat transfer. All objects with temperatures above absolute zero can generate heat radiation. The higher the temperature, the greater the total energy radiated and the more short-wave components. The spectrum of thermal radiation is a continuum, and the wavelength coverage can theoretically range from 0 to ∞. The general thermal radiation mainly depends on the longer wavelength visible light and infrared rays. Since the propagation of electromagnetic waves does not require any medium, thermal radiation is the only way to transfer heat in a vacuum.