Determine the overall unit thermal resistance (the R 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 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 (glass) (Wall without glass 80%).

Unit thermal resistance (the *R*-value) of common components used in buildings

Component	*R*-Value $m^2 \cdot °C/W$	*R*-Value $ft^2 \cdot h \cdot °F/Btu$
Outside surface (winter)	0.030	0.17
Outside surface (summer)	0.044	0.25
Inside surface, still air	0.12	0.68
Plane air space, vertical, ordinary surfaces ($\varepsilon_{eff} = 0.82$):		
13 mm ($\frac{1}{2}$ in)	0.16	0.90
20 mm ($\frac{3}{4}$ in)	0.17	0.94
40 mm (1.5 in)	0.16	0.90
90 mm (3.5 in)	0.16	0.91
Insulation, 25 mm (1 in)		
Glass fiber	0.70	4.00
Mineral fiber batt	0.66	3.73
Urethane rigid foam	0.98	5.56
Stucco, 25 mm (1 in)	0.037	0.21
Face brick, 100 mm (4 in)	0.075	0.43
Common brick, 100 mm (4 in)	0.12	0.79
Steel siding	0.00	0.00
Slag, 13 mm ($\frac{1}{2}$ in)	0.067	0.38
Wood, 25 mm (1 in)	0.22	1.25
Wood stud, nominal 2 in × 4 in (3.5 in or 90 mm wide)	0.63	3.58
Wood stud, nominal 2 in × 6 in (5.5 in or 140 mm wide)	0.98	5.56
Clay tile, 100 mm (4 in)	0.18	1.01
Acoustic tile	0.32	1.79
Asphalt shingle roofing	0.077	0.44
Building paper	0.011	0.06
Concrete block, 100 mm (4 in):		
Lightweight	0.27	1.51
Heavyweight	0.13	0.71
Plaster or gypsum board, 13 mm ($\frac{1}{2}$ in)	0.079	0.45
Wood fiberboard, 13 mm ($\frac{1}{2}$ in)	0.23	1.31
Plywood, 13 mm ($\frac{1}{2}$ in)	0.11	0.62
Concrete, 200 mm (8 in)		
Lightweight	1.17	6.67
Heavyweight	0.12	0.67
Cement mortar, 13 mm (1/2 in)	0.018	0.10
Wood bevel lapped siding, 13 mm × 200 mm (1/2 in × 8 in)	0.14	0.81

	$\frac{m^2\,°C}{W}$	$\frac{m^2\,°C}{W}$
	Insulation	Wood Studs
1. Outside air surface	0.03	0.3
2. Wood bevel (13*200) mm	0.14	0.14
3. Plywood (13 mm)	0.11	0.11
4.a Urethane rigid foam	$0.98*\frac{90}{25} = 3.528$	/
4.b Wood Studs (90 mm)	/	0.63
5. Gypsum Wallboard (13 mm)	0.079	0.079
6. Inside air surface	0.12	0.12

The R_unit values are respectively:

$R'_{\text{with insulation}}$ =	$4{,}007 \ \frac{m^2\,°C}{W}$	
$R'_{\text{with wood studs}}$ =		$1{,}379 \ \frac{m^2\,°C}{W}$

$R'_{tot} = R*A \quad => \quad R = \frac{R'tot}{A}$ (R' is R_{unit})

$R_{unit} = \frac{1}{U} \quad => \quad \frac{1}{R'} = U$

$\frac{1}{R\ tot} = \frac{1}{R\ insul} + \frac{1}{R\ wood} \quad => \quad \frac{A\ tot}{R'tot} = \frac{A\ insul}{R'\ insul} + \frac{A\ wood}{R'\ wood}$

$U_{tot} * A_{tot} = U_{ins} * A_{ins} + U_{wood} * A_{wood}$

$U_{tot} = U_{ins} * \frac{A\ insul}{A\ tot} + U_{wood} * \frac{A\ wood}{A\ tot}$

$U_{tot} = U_{ins} * 0.75 + U_{wood} * 0.25$ (insulated cavity -> 75% = 0.75 of the heat transmission area
studs, plates, sills + headers(/studs) -> 21+4 % = 0.25)

$U_{insul} = \frac{1}{R'\ insul} = \frac{1}{4.007} = 0{,}2496 \ \frac{W}{m^2\,°C}$

$U_{wood} = \frac{1}{R'\ wood} = \frac{1}{1.379} = 0{,}7252 \ \frac{W}{m^2\,°C}$

$U_{tot} = 0{,}2496 * 0.75 + 0{,}7252 * 0.25 = 0.1872 + 0.1813 = 0.3685 \ \frac{W}{m^2\,°C}$

$A_{tot} = 50 * 2.5 * 0.8 = 100\ m^2$ (0.8 is the 80% of the wall without glass)

$\Delta T = 22 - (-2) = 24\ °C$

$Q_{tot} = U_{tot} * A_{tot} * \Delta T = 884.4\ W$

THE RADIATION AND THE RADIATIVE HEAT TRANSFER

In physics, the term radiation is generally used to indicate the set of phenomena characterized by the transport of energy in space, where there are different surroundings conditions (in which there isn't thermal equilibrium). Typical examples of radiation are light and heat.
So, radiation differs from conduction and convection because it doesn't require the presence of a material medium to take place.
A particular type of radiation is constituted by electromagnetic waves: they represent the energy emitted by matter as a result of the changes in the electronic configurations of the molecules.
Electromagnetic waves transport energy, and this energy, once in contact with another medium, produces a change in heat. An increase in temperature is caused by an increase in energy in the movement of the particles that compose it.
Electromagnetic waves that transport energy is characterized by a constant, finite vacuum speed of approximately 299792 km/s (rounded to 3.0 x 108 m/s), indicated by *c*, from a particular frequency *v* and its wavelength, indicated with the symbol λ.
The frequency ν is defined as the number of wavelengths that pass in a second for a given point in space:
$\nu = c\lambda$
Higher is the wave frequency value, smaller its wavelength is, so the speed of light is constant for every electromagnetic radiation in a vacuum.
Visible light (or better, visible light for the human eye) is the electromagnetic radiation with a wavelength ranging from about 380 nm of violet to about 760 nm for red.

The graphic represents the variety of the blackbody emissive power with wavelength for several temperatures. The axis of wavelength is on a logarithmic scale, while the axis of the emissive power is on a linear scale.
The amount of *emitted radiation* increases with increasing temperature.
The radiation emitted by the sun, which is considered to be a blackbody at 5800 K, reaches its *peak* in the visible light region of the spectrum.
Surfaces at T < 800 K emit almost entirely in the infrared region and thus are not visible to the eye unless they reflect light coming from other sources