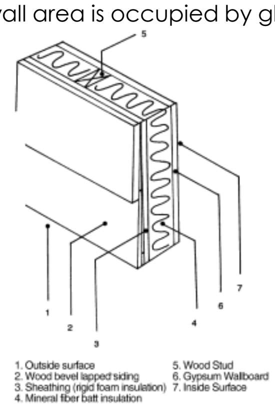
27 October 2019 16:03

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 glass fiber insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm wood fiberboard 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 -2C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing.



	Case 1: wood R_unit= $\frac{L}{K}$	Case 2: insulation R_unit= $\frac{L}{K}$
Outside air	0.030	0.030
Wood bevel 1.	0.14	0.14
13 mm plywood	0.11	0.11
urethane rigid foam insulation	-	0.98*$\frac{90}{25}$=3.528
13 mm gypsum board	0.079	0.079
Wood studs	0.63	-
Inside surface	0.12	0.12
R' (sum)	1.109°$\frac{C}{Wmq}$	4.007°$\frac{C}{Wmq}$

R'tot= R*A → R=$\frac{R'tot}{A}$

R_unit=$\frac{1}{U}$ → $\frac{1}{R'}$=U

$\frac{1}{\text{Rtot}} = \frac{1}{\text{Rinsul}} + \frac{1}{\text{Rwood}} \rightarrow \frac{\text{Atot}}{\text{R'tot}} = \frac{Ainsul}{\text{R'insul}} + \frac{\text{Awood}}{\text{R'wood}}$

Utot*Atot=Uins+Uwood*Awood

Utot = Uinsul* $\frac{\text{Ainsul}}{\text{Atot}}$+Uwood*$\frac{\text{Awood}}{\text{Atot}}$

Utot= Uinsul*0.75+Uwood*0.25

Uinsul= $\frac{1}{R'insul}$= $\frac{1}{4.007}$=0.2495°$\frac{C}{W}$

Uwood= $\frac{1}{1.109}$=0.9017°$\frac{C}{W}$

Heat transfer coefficient:

Utot=0.2495*0.75+0.9017*025=0.4125°$\frac{W}{C*mq}$

$R' = \frac{1}{Utot} \quad \frac{1}{0.4125} = 2.424° \frac{W}{C*mq}$

Atot = 50*2.5*0.8=100 m^2 (80% of the wall without windows)

$\Delta T = 22-(-2) = 24$ °C

Heat loss through the walls:

$\dot{Q}tot$ =Utot*Atot*ΔT=0.4125*100*24=990W

Radiation and radiative heat transfer:

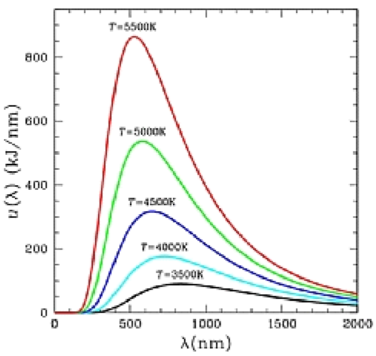
Heat radiation is electromagnetic radiation emitted from the body as a result of the thermal motion of the charged particles that make up it. This motion is due to the fact that in the body that is at a temperature above the absolute zero, the particles that make up it move randomly. Since every charge under acceleration emits electromagnetic radiation, each body emits heat radiation.

Examples of thermal radiation include the visible light and infrared light emitted by a flame lamp, sub-red radiation emitted by animals that can be detected with a thermal camera and the microwave radiation. Thermal radiation is different from heat convection and heat conduction - a person near a fire will feel heat radiated from the fire, even when the environment is cold.

When the object has physical properties that characterize a black body at thermodynamic equilibrium, the radiation is called black body radiation.
The Planck formula describes the radiation spectrum of a black body, which depends only on temperature.
Wien's displacement law determines the frequency at which the maximum emission will be and Stefan-Boltzmann's law determines the total radiation intensity.

Wien's displacement law, is a basic law of spectroscopy, which deals with black body radiation. Originally, the Wien's law was an empirical law derived by the German physicist Wilhelm Wien in the late 19th century from observations only. In 1900, Max Planck proposed a theory explaining the phenomenon of black body radiation, and in particular the Winn law. This theory, which in some sense was the basis of quantum theory, is today considered the accepted theory for the phenomenon.

Wien law is important not only in spectroscopy, but also in astrophysics. The law explains why hot stars glow in blue (shorter wavelength), and cold stars glow in red (longer wavelength). Using the Wien law, you can set color temperature.



Stefan-Boltzmann's law is a physical law that states that the radiation flux emitted from a black body is proportional to the fourth strength of its temperature. The law is of great importance in astrophysics, as it helps determine the absolute size of a star given its temperature, which can be found with the Wien law.

The law was formulated empirically by physicist Joseph Stefan Austrian of Slovenian origin and his student Ludwig Boltzman separately and independently, as a result of observations of black body radiation. The mathematical wording of the law is:

$$I = \sigma T^4$$

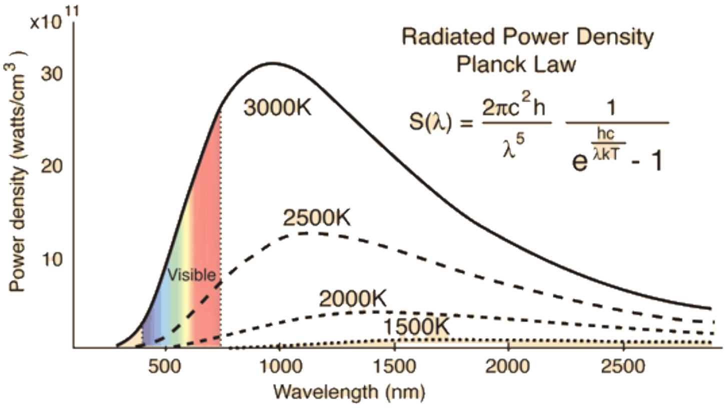
$$\sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.670373 \times 10^{-8} \left[\frac{Joule}{m^2 \times sec \times K^4}\right]$$

Black body is an ideal object that absorbs perfectly electromagnetic radiation at all wavelengths, without repetition or transfer. A black body emits electromagnetic radiation that depends solely on its temperature, according to Planck's law. This radiation is called black body radiation. The radiation emitted does not depend on the offending radiation, except for the effect of this on the body temperature. An ideal black body is a good approximation for describing the radiation emitted by many hot bodies: sunlight, incandescent light, and animal underbody radiation.

A black body radiates at all wavelengths, depending on the wavelength and temperature, in accordance with Planck Law. A black body at a temperature lower than 700° Kelvin (430° C degrees) emits very little radiation in the visible light, and radiates mainly at lower frequencies, such as radio waves, microwaves, and reds.

The reason for the form of the Planck formula is the creation of photons with discrete energies, quantum. This understanding, together with the explanation of the photoelectric effect, marked the beginning of quantum theory.

In reality, a black body is a good approximation of many surfaces, especially natural surfaces. There are also devices that simulate a high-precision black body for industrial and scientific uses.



Electromagnetic wave:

The electromagnetic spectrum is the collection of all electromagnetic waves at all possible frequencies.
The spectrum of different bodies contains physical information about them: for example, starlight has a lot of information about their composition, surface temperature, velocity and more. Various areas of the electromagnetic spectrum are used in many fields, where information communication (wired, wireless and cellular telephony, fiber optic satellite communications and more), medicine (body heat measurement, blood pressure measurement, non-invasive diagnostics and more) are used in many other fields of science. To different areas of the electromagnetic spectrum. The field of physics that deals with the electromagnetic spectrum is electromagnetism.
in frequency or wavelength only. The speed of light links the frequency along the wave based on the formula:

$$f = \frac{c}{\lambda}, \quad \text{or} \quad f = \frac{E}{h}, \quad \text{or} \quad E = \frac{hc}{\lambda},$$