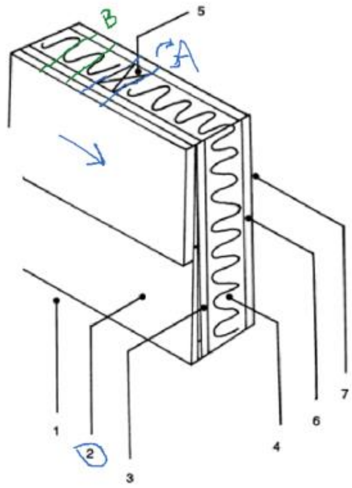
Task 1: you should complete the modified example of simplified wall calculations that you went through in the assignment of week 3 and find the total heat transfer through wall

Task 2: 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

Task 1

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-centre 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 bevel l.	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane rigif foam	No	0.98*90/25=3.52
Wood studs	0.63	No
Gypsum board	0.079	0.079
Inside surface	0.12	0.12



$R'_{withWood}$ = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 $= 1.109\ m^2.°C/W$

$R'_{withIns}$ = 0.03 + 0.14 + 0.11 + 3.52 + 0.079 + 0.12 = 3.999 m^2. °C/W

$$U_{Wood} = \frac{1}{R'_{withWood}} = \frac{1}{1.109\ m^2.\ °C/W} = 0{,}9017\ Wm^2/.°C$$

$$U_{Ins} = \frac{1}{R'_{withIns}} = \frac{1}{3.999\ m^2.\ °C/W} = 0{,}2500\ Wm^2/.°C$$

$$\frac{1}{R'_{total}} = \frac{1}{R'_{withwood}} + \frac{1}{R'_{withIns}}$$

$$\frac{A_{total}}{R'_{total}} = \frac{A_{wood}}{R'_{wood}} + \frac{A_{Ins}}{R'_{withIns}}$$

$$U_{total} = U_{wood} x \frac{A_{wood}}{A_{total}} + U_{Ins} x \frac{A_{Ins}}{A_{total}}$$

$$= U_{wood}\ x\ (21\%+4\%) + U_{Ins}\ x\ 75\%$$
$$= (0{,}9017\ x\ 25\%) + (0{,}2500\ x\ 75\%)$$
$$= 0{,}4129\ \ Wm^2/.\ °C$$

Overall unit thermal resistance;

$$R_{value} = \frac{1}{U_{total}}$$
$$= \frac{1}{0{,}4129\ \ Wm^2/.\ °C} = 2{,}421 m^2.\ °C/W$$

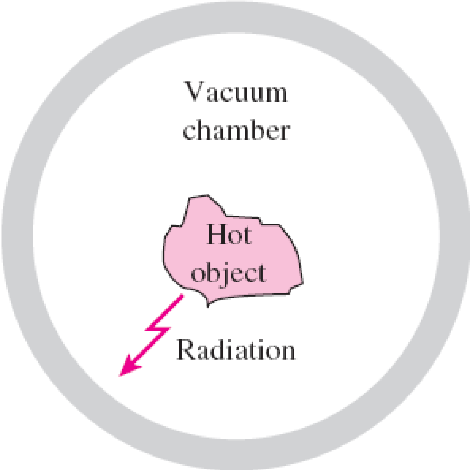
The rate of heat loss through the walls

$$Q_{total} = U_{total}\ x\ A_{total}\ x\ \ \Delta T$$

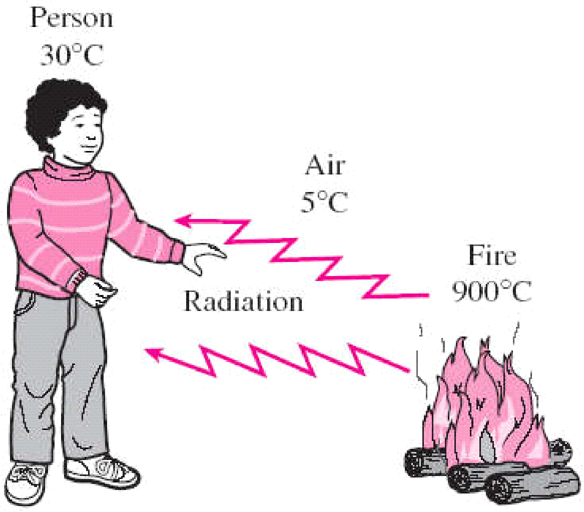
$$= 0{,}4129\ Wm^2/.\ °C\ x\ 50\ x\ 2.5\ x\ 0.8\ x\ 24$$
$$= 990{,}96\ W$$

Task 2

Heat transfer between the object and the chamber could not have taken place by conduction or convection, because these two mechanisms cannot occur in a vacuum. Therefore, heat transfer must have occurred through another mechanism that involves the emission of the internal energy of the object.This mechanism is radiation.



Radiation differs from the other two heat transfer mechanisms in that it does not require the presence of a material medium to take place. In fact, energy transfer by radiation is fastest (at the speed of light) and it suffers no attenuation in a vacuum. Also, radiation transfer occurs in solids as well as liquids and gases. In most practical applications, all three modes of heat transfer occur concurrently at varying degrees. But heat transfer through an evacuated space can occur only by radiation. For example, the energy of the sun reaches the earth by radiation.



Electromagnetic waves transport energy just like other waves, and all electromagnetic waves travel at *the speed of light* in a vacuum, which is $c_0 = 2.9979 \times 10^8$ *m/s*. Electromagnetic waves are characterized by their *frequency* or *wavelength*. These two properties in a medium are related by

$$\lambda = \frac{c}{\nu}$$

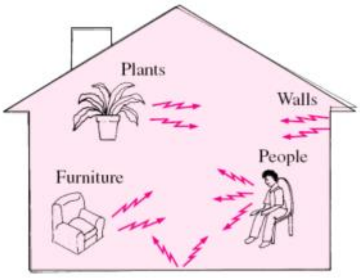
where *c* is the speed of propagation of a wave in that medium. The speed of propagation in a medium is related to the speed of light in a vacuum by $c = c_0/n$, where *n* is *the index of refraction* of that medium. The refractive index is essentially unity for air and most gases, about 1.5 for glass, and 1.33 for water. The commonly used unit of wavelength is the *micrometer* or *micron*, where 1 micrometer = 10^{-6} m. Unlike the wavelength and the speed of propagation, the frequency of an electromagnetic wave depends only on the source and is independent of the medium through which the wave travels. The *frequency* (the number of oscillations per second) of an electromagnetic wave can range from less than a million Hz to a septillion Hz or higher, depending on the source. Note that the wavelength and the frequency of electromagnetic radiation are inversely proportional.

It has proven useful to view electromagnetic radiation as the propagation of a collection of discrete packets of energy called photons or quanta, as proposed by Max Planck in 1900 in conjunction with his quantum theory.

$$e = h\nu = \frac{hc}{\lambda}$$

Thermal Radiation

Note from the second part of these equation that the energy of a photon is inversely proportional to its wavelength. Therefore, shorter-wavelength radiation possesses larger photon energies. It is no wonder that we try to avoid very-short-wavelength radiation such as gamma rays and X-rays since they are highly destructive. The type of electromagnetic radiation that is pertinent to heat transfer is the thermal radiation emitted as a result of energy transitions of molecules, atoms, and electrons of a substance. Temperature is a measure of the strength of these activities at the microscopic level, and the rate of thermal radiation emission increases with increasing temperature. Thermal radiation is continuously emitted by all matter whose temperature is above absolute zero. That is, everything around us such as walls, furniture, and our friends constantly emits (and absorbs) radiation.



Light

A body that emits some radiation in the visible range is called a light source. The sun is obviously our primary light source. The electromagnetic radiation emitted by the sun is known as solar radiation, and nearly all of it falls into the wavelength band 0.3–3 mm. Almost half of solar radiation is light (i.e., it falls into the visible range), with the remaining being ultraviolet and infrared.

Black Body Radiation

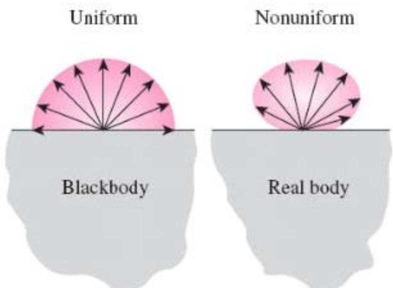
Different bodies may emit different amounts of radiation per unit surface area, even when they are at the same temperature. Thus, it is natural to be curious about the maximum amount of radiation that can be emitted by a surface at a given temperature. Satisfying this curiosity requires the definition of an idealized body, called a blackbody, to serve as a standard against which the radiative properties of real surfaces may be compared. A blackbody is defined as a perfect emitter and absorber of radiation. At a specified temperature and wavelength, no surface can emit more energy than a blackbody. A blackbody absorbs all incident radiation, regardless of wavelength and direction.

The radiation energy emitted by a blackbody:

$$E_b(T) = \sigma T^4 \qquad (\mathrm{W/m^2})$$

$$\sigma = 5.670 \times 10^{-8}\ \mathrm{W/m^2 \cdot K^4}$$

Stefan–Boltzmann constant



Spectral blackbody emissive Power:

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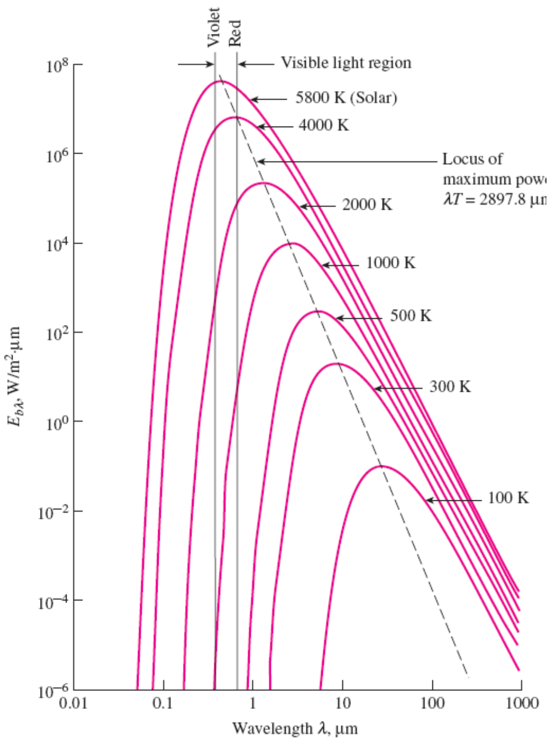
$$E_{b\lambda}(\lambda, T) = \frac{C_1}{\lambda^5[\exp(C_2/\lambda T) - 1]} \qquad (\mathrm{W/m^2 \cdot \mu m})$$ Planck's law

$$C_1 = 2\pi h c_0^2 = 3.74177 \times 10^8 \ \mathrm{W \cdot \mu m^4/m^2}$$
$$C_2 = h c_0/k = 1.43878 \times 10^4 \ \mathrm{\mu m \cdot K}$$

$k = 1.38065 \times 10^{-23}$ J/K Boltzmann's constant



The variation of the blackbody emissive power with wavelength for several temperatures.

The wavelength at which the peak occurs for a specified temperature is given by Wien's displacement law:

$$(\lambda T)_{\text{max power}} = 2897.8 \ \mathrm{\mu m \cdot K}$$