Assignment 4
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Question 1

A wood frame wall that is built around 38mm x 90mm wood studs with a center-to-center distance of 400mm.The 90mm-wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finish with 13-mm gypsum wallboard and the outside with 13-mm plywood and 13-mm x 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% of the heat transmission area while the studs, plates, and sills constitute 21%. The headers constitute 4 % of the area, and they can be treated as studs.

Find the 2 R_{Unit} values; determine the overall unit thermal resistance and the overall heat transfer coefficient.

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 ˚C. Take the indoor design temperature to be 22 ˚C and assume 20% of the wall is occupied by glazing.

	WOOD	**INSULATION**
OUTSIDE AIR	0.03	0.03
WOOD BEVEL (13*20mm)	0.14	0.14
PLYWOOD (13mm)	0.11	0.11
URETHANE RIDGID FOAM INSULATION (90mm)	-	0.98*90/25= **3.5**
WOOD STUDS (90mm)	0.63	-
GYPSUM BOARD (13mm)	0.079	0.079
INSIDE SURFACE	0.12	0.12
TOTAL $m^2.C/W$	**1.11**	**3.98**

$R'_{with\ wood}$ = (0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12) $m^2.C/W$ = 1.109 $m^2.C/W$

$R'_{with\ insulation}$ = (0.03 + 0.14 + 0.11 + 3.5 + 0.079 + 0.12) $m^2.C/W$ = 4.007 $m^2.C/W$

$$U_{wood} = \frac{1}{R'_{with\ wood}} = \frac{1}{1.109\ m2.C/W} = 0.9017\ m^2.C/W$$

$$U_{insulation} = \frac{1}{R'_{with\ wood}} = \frac{1}{4.007\ m2.C/W} = 0.2496\ m^2.C/W$$

$$\frac{1}{R'_{total}} = \frac{1}{R'_{wood}} + \frac{1}{R_{insulation}},\ R = \frac{R'}{A};\ \text{i.e.},\ \frac{1}{R} = \frac{A}{R'}$$

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

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

i.e. , $A_{total} * U_{total} = A_{wood} * U_{wood} + A_{insulation} * U_{insulation}$

$U_{total} = U_{wood} * \frac{Awood}{Atotal} + U_{insulation} * \frac{Ainsulation}{Atotal}$

$= (21\% + 4\%) * U_{wood} + 75\% * U_{insulation}$

$= 25\% * 0.9017\ m^2.C/W + 75\% * 0.2496\ m^2.C/W$

$= 0.4126\ m^2.C/W$

Overall thermal resistance $R_{value} = \frac{1}{Utotal} = \frac{1}{0.4126}\ m2.C/W = 2.4237\ m^2.C/W$

Rate of heat loss through walls $Q_{total} = U_{\underline{total}} * A_{\boldsymbol{total}} * \Delta T$

$= 0.4126\ m^2.C/W * 50m * 2.5m * (1-20\%) * 22 – (-2\ ^\circ C) = 990.24W$

<u>Question 2</u>

In 2 pages, write a summary about radiation and radiative heat transfer.

1. Radiation definition:

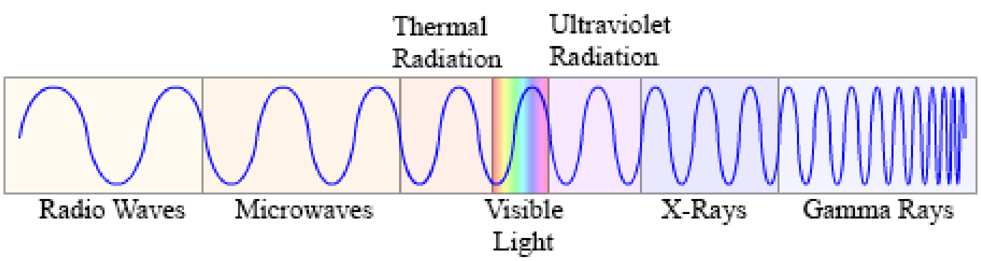
Radiation is the process of emitting energy through a medium or space in the form of waves or particles. Sunshine is one of the most familiar forms of radiation. It delivers light and heat. Radiation includes particles and electromagnetic waves that are emitted by some materials and carry energy.

Ionising radiation has enough energy to ionise (remove an electron from an atom) which can change the chemical composition of the material. Non-ionising radiation has less energy but can still excite molecules and atoms causing them to vibrate faster.

2. Electromagnetic waves:

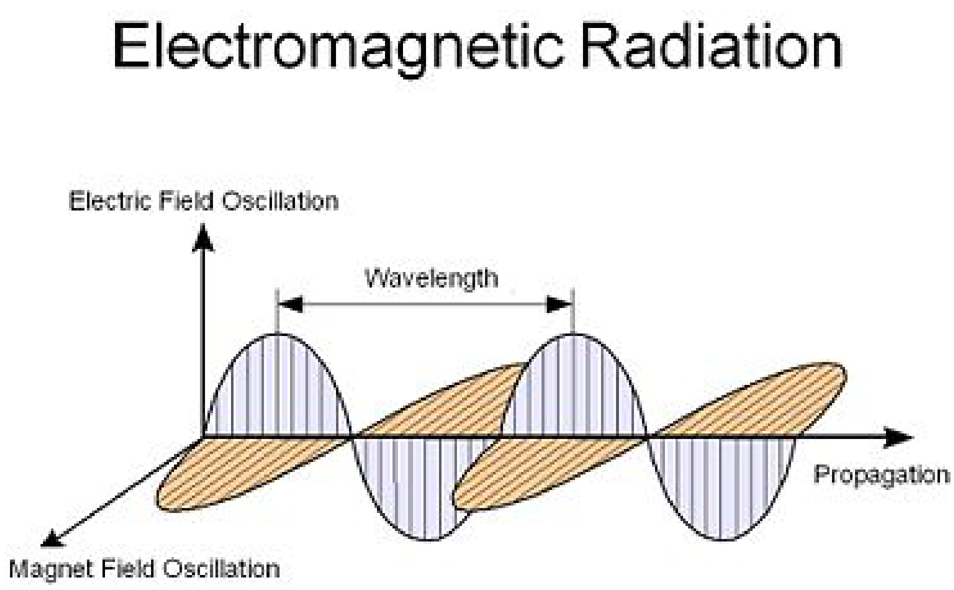
Electromagnetic radiation can be considered as a wave of electric and magnetic energy travelling through a vacuum or a material. The electromagnetic spectrum includes radio waves, microwaves, infrared rays, light rays, UV rays, X-rays and gamma rays. All electromagnetic radiation is transmitted through empty space at the speed of light.

These properties also determine their ability to travel through objects, their heating effects and



their effect on living tissue. Electromagnetic radiation is created when an atomic particle, such as an electron, is accelerated by an electric field, causing it to move. The movement produces oscillating electric and magnetic fields, which travel at right angles to each other in a bundle of light energy called a photon. Photons travel in harmonic waves at the fastest speed possible in the universe: 186,282 miles per second (299,792,458 meters per second) in a vacuum, also known as the speed of light. The different forms of electromagnetic radiation are distinguished from each other by:

- → their wavelength
- → the amount of energy they transfer.



Electromagnetic waves are formed when an electric field (shown in blue arrows) couples with a magnetic field (shown in red arrows). Magnetic and electric fields of an electromagnetic wave are perpendicular to each other and to the direction of the wave.

3. Black body

All objects with a temperature above absolute zero (0 K, -273.15 $^{\circ}$C) emit energy in the form of electromagnetic radiation. A black body is one that absorbs all the electromagnetic radiation (light...) that strikes it. To stay in thermal equilibrium, it must emit radiation at the same rate as it absorbs it so a black body also radiates well.It is a hypothetical object which is a “perfect” absorber and a “perfect” emitter of radiation over all wavelengths.

The spectral distribution of the thermal energy radiated by a blackbody depends only on its temperature.

Radiation energy emitted by a black body is $E(T) = \sigma T^4 (W/m^2)$