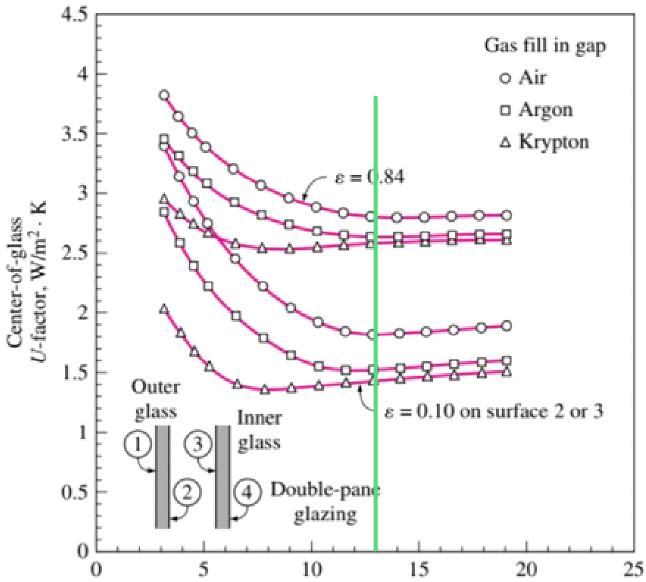
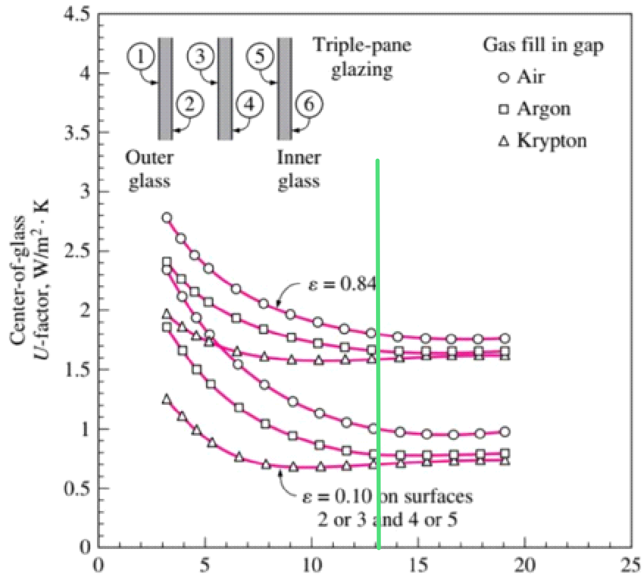
Task 1:

Using the diagrams given in the presentation calculate how much (%) is the effect of applying different modifications (changing the gas, adding an extra pane, using a low emissivity coating) on the U value with respect to a benchmark case of double layer with air and no coating? (keep the gap thickens to be 13 mm)





<u>With double pane glazing: (when ε=0.10):</u>
The U factor when using Krypton gas is 1.4 $\frac{W}{m^2K}$ while with Argon gas the U factor is 1.5$\frac{W}{m^2}$ → it notable that there is not so much difference, but using air in the gap bwtween the two pane the U factor is increasing 1.8$\frac{W}{m^2}$
<u>when ε=0.84</u> - the U factor of Krypton and Argon gases are almost the same 2.1 $\frac{W}{m^2}$ while the Ufactor of the air is 2.3$\frac{W}{m^2}$

<u>With triple pane glazing: (when ε=0.10):</u>
The U factor when using Krypton gas is 0.7 $\frac{W}{m^2K}$ while with Argon gas the U factor is 0.8$\frac{W}{m^2}$ → it notable that there is not so much difference, but using air in the gap bwtween the three pane the U factor is increasing 1$\frac{W}{m^2}$
<u>when ε=0.84</u> - the U factor of Krypton and Argon gases are almost the same 1.6 $\frac{W}{m^2}$ while the Ufactor of the air is 1.8$\frac{W}{m^2}$

- Comparing a double glazed window to a triple glazing window, it notable that the U factor varies significantly changing (by almost half)
- The differences between the emissivity in a double glazed window are also significant and almost triple up. Compared to a window with triple glazing, which values only multiply itself.

Task 2:

Consider the house that we analyzed in the last two examples, calculate the heating and cooling load of the other windows which are fixed 14.4 m2 on the west, fixed 3.6 m2 on the south and an operable 3.6 m2 on the south (the same window and frame type). How much does the total value change if I change the frame of the window from wooden one to aluminum ?

The net area of walls (excluding doors and windows) of a building located in Piacenza is 105.8 m2, the calculated U value is 0.438 W/m2K for the winter and 0.435 w/m2K for the summer. Find the corresponding heating and cooling load.

PIACENZA, Italy WMO#: **160840**

Lat: **44.92N** Long: **9.73E** Elev: **138** StdP: **99.68** Time Zone: **1.00 (EUW)** Period: **89-10** WBAN: **99999**

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
			99.6%			99%			0.4%		1%				
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
1	-6.2	-4.8	-11.6	1.4	3.1	-8.8	1.8	1.8	8.8	5.6	7.7	6.2	2.1	250	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
		0.4%		1%		2%		0.4%		1%		2%				
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
8	11.9	33.1	22.7	31.9	22.4	30.3	21.8	24.6	30.2	23.7	29.2	22.9	28.3	2.4	90	(2)

$\Delta T_{cooling} = 31.9 - 24 = 7.9\,°C$

$\Delta T_{heating} = 20 - (-4.8) = 24.8\,°C$

$DR = 11.9\,°C$

The RLF method uses the following to estimate cooling load:

$$q_{opq} = A \times \mathrm{CF}_{opq}$$

$$\mathrm{CF}_{opq} = U(\mathrm{OF}_t\,\Delta t + \mathrm{OF}_b + \mathrm{OF}_r\mathrm{DR})$$

where

q_{opq} = opaque surface cooling load, W
A = net surface area, m^2
CF = surface cooling factor, W/m^2
U = construction U-factor, $W/(m^2 \cdot K)$
Δt = cooling design temperature difference, K
$\mathrm{OF}_t, \mathrm{OF}_b, \mathrm{OF}_r$ = opaque-surface cooling factors (see Table 7)
DR = cooling daily range, K

Surface Type	OF_t	OF_b, K	OF_r
Ceiling or wall adjacent to vented attic	0.62	$14.3\alpha_{roof} - 4.5$	–0.19
Ceiling/roof assembly	1	$38.3\alpha_{roof} - 7.0$	–0.36
Wall (wood frame) or door with solar exposure	1	8.2	–0.36
Wall (wood frame) or door (shaded)	1	0	–0.36
Floor over ambient	1	0	–0.06
Floor over crawlspace	0.33	0	–0.28
Slab floor (see Slab Floor section)			

α_{roof} = roof solar absorptance (see Table 8).

$Q_{load} = 105.8*82.040 = 8679.834\frac{W}{m^2}$

$CF_{opq} = U(OF_t\Delta t + OF_b + OF_r DR) = 0.438(1*7.9+8.2-0.36*11.9) = 82.040\frac{W}{m^2}$

$Q_{load} = 105.8*81.478 = 8620.38\,\frac{W}{m^2}$

$CF_{opq} = U(OF_t\Delta t + OF_b + OF_r DR) = 0.435(1*7.9+8.2-0.36*11.9) = 81.478\frac{W}{m^2}$

$Q_{load-south} = 3.6*82.040 = 295.344\frac{W}{m^2}$

$CF_{opq} = U(OF_t\Delta t + OF_b + OF_r DR) = 0.438(1*7.9+8.2-0.36*11.9) = 82.040\frac{W}{m^2}$

$Q_{load-west} = 14.4*81.478 = 1173.283\frac{W}{m^2}$

$CF_{opq} = U(OF_t\Delta t + OF_b + OF_r DR) = 0.435(1*7.9+8.2-0.36*11.9) = 81.478\frac{W}{m^2}$

The U-factors for various frames are listed in the Table as a function of spacer materials and the glazing unit thicknesses. The U-factor of metal framing and thus the rate of heat transfer through a metal window frame is more than three times that of a wood or vinyl window frame.

Frame material	*U*-factor, $W/m^2 \cdot °C$*
Aluminum:	
Single glazing (3 mm)	10.1
Double glazing (18 mm)	10.1
Triple glazing (33 mm)	10.1
Wood or vinyl:	
Single glazing (3 mm)	2.9
Double glazing (18 mm)	2.8
Triple glazing (33 mm)	2.7

$Q_{load-south}$ =3.6*524.456=1888.044$\frac{W}{m^2}$

$CF_{opq-wood} = U(OF_t\Delta t + OF_b + OF_r DR)$ = 2.8(1*7.9+8.2-0.36*11.9)=524.456$\frac{W}{m^2}$

$Q_{load-west}$ = 14.4*1891.79=27241.784$\frac{W}{m^2}$

$CF_{opq-aluminium} = U(OF_t\Delta t + OF_b + OF_r DR)$ = 10.1(1*7.9+8.2-0.36*11.9)=1891.79$\frac{W}{m^2}$

When calculating the total load, it notable that there is not so much difference between the materials. The only significant difference is in the U factor.