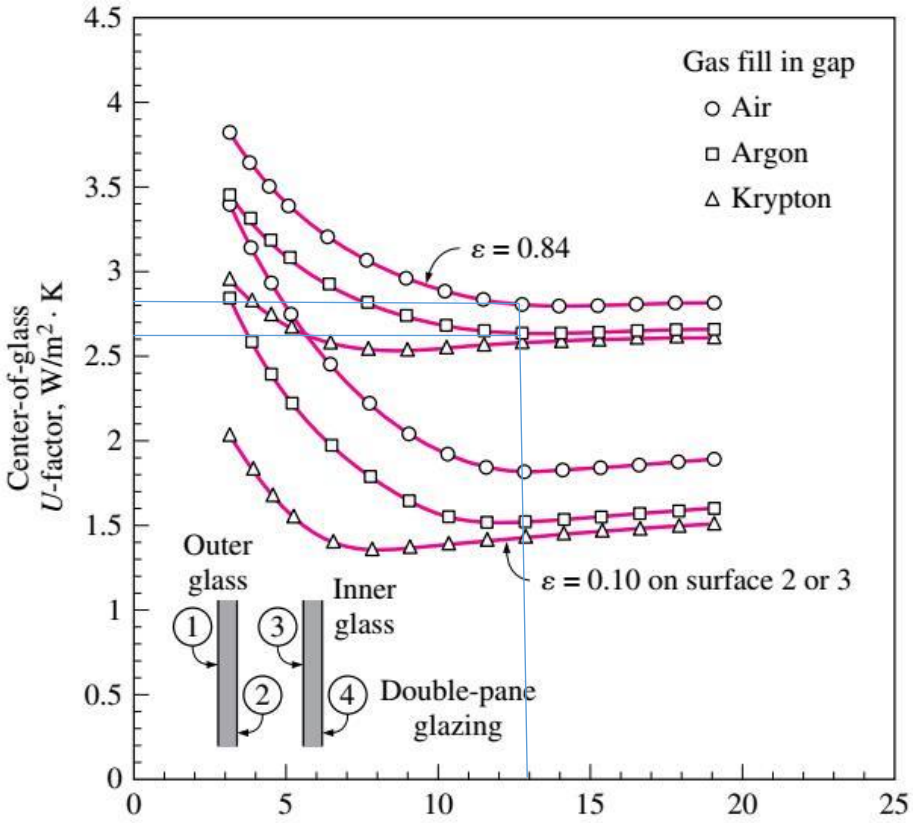
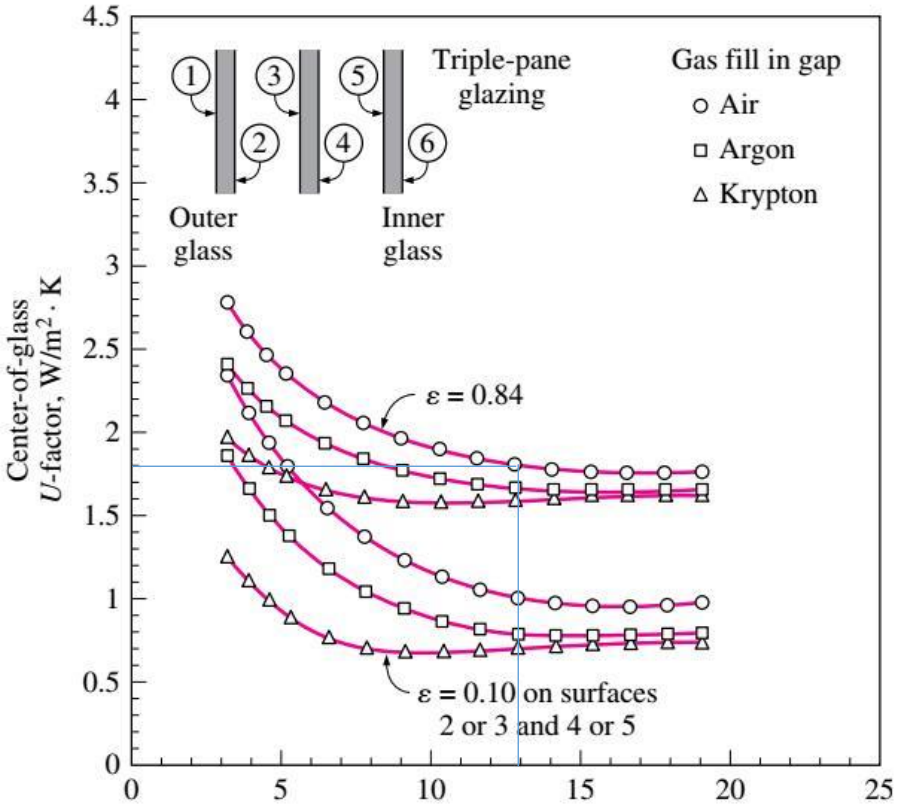
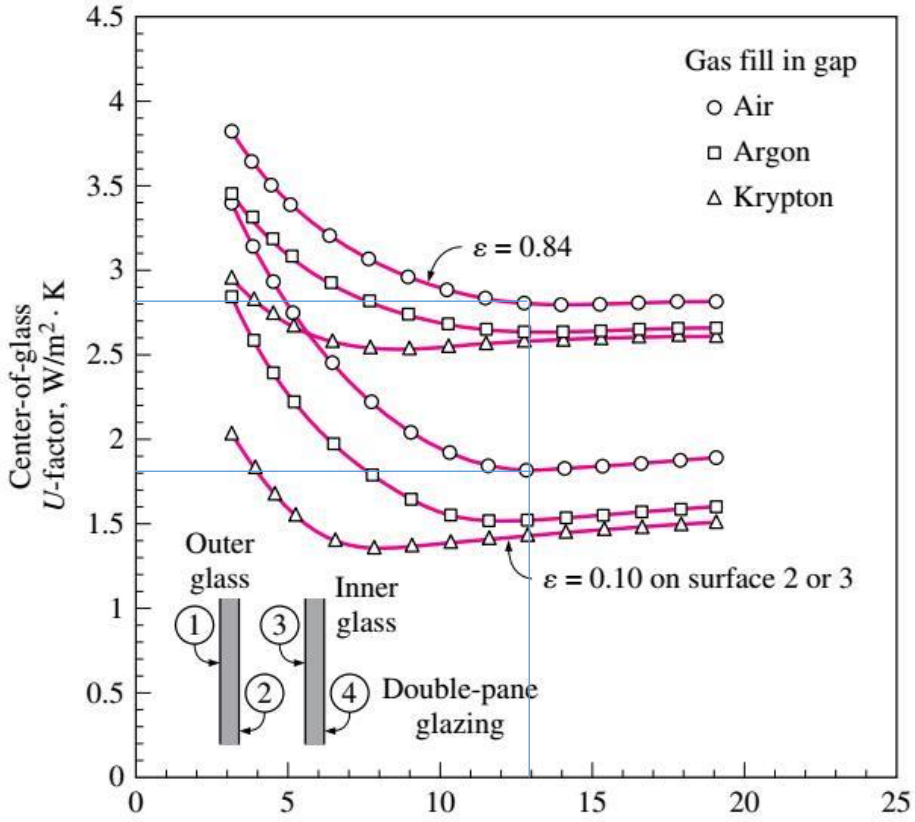
Task 1:



1) **Changing the gas:** When we change the gas from air to Argon, the Center-of-glass U-factor changes from 2.8W/m^2K to 2.6 W/m^2K, (2.8-2.6)/2.8=7.1%. So the U-factor decreased by 7.1%



2) Adding an extra pane： When we add an extra pane, the Center-of-glass U-factor changes from 2.8W/m^{2}K to 1.8 W/m^{2}K, (2.8-1.8)/2.8=35.7%. So the U-factor decreased by 35.7%



3) **Using a low emissivity coating：** When we use a low emissivity coating (fromε=0.84 to ε=0.1), the Center-of-glass U-factor changes from 2.8W/m^{2}K to 1.8 W/m^{2}K, (2.8-1.8)/2.8=35.7%. So the U-factor decreased by 35.7%

Task 2:

1) The cooling load of the fixed 14.4 m² window on the West:

$$CF_{window_{\text{west}}heatTrasnferPart} = U_{window_{\text{west}}}\left(\Delta T_{cooling} - 0.46\,DR\right)$$

$$= 2.84\,(7.9 - 0.46 * 11.9) = \ 6.9\frac{W}{m^2}$$

$$PXI_{window_{west}} = E_D + E_d = 559 + 188 = 747$$

SHGC = 0.54
No internal shading so IAC = 1
From the table for west window of a detached house FFs = 0.56

$$CF_{window_{\text{west}}\_IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 747\ * 0.54\ * 1\ * 0.56$$

$$= 225.9\frac{W}{m^2}$$

$$CF_{window_{\text{west}}} = CF_{window_{\text{west}}heatTrasnferPart} + CF_{window_{\text{west}}\_IrradiationPart} =$$

$$6.9 + 225.9 = 232.8\frac{W}{m^2}$$

$$Q_{window_{\text{west}}} = \ CF_{window_{\text{west}}} \times A_{window_{west}} = 232.8 * 14.4 = 3352.3\ W$$

The heating load of the fixed 14.4 m² window on the West:

$$U_{window_{west}} \ = 2.84\frac{W}{\text{m}^2K}$$

$$HF_{window_{west}} \ = \ U_{window_{west}} \times \Delta T_{\text{heating}} = 2.84\ * 24.8 = 70.4\frac{W}{m^2}$$

$$Q_{window_{west}} = \ \ HF_{window_{west}} \times A_{window_{west}} = 70.4 * \ 14.4 \ = \ 1014.2\ W$$

When we change the frame of the window from wooden to aluminum:

$U_{window_{\text{west}}} = \ 3.61\frac{W}{m^2}$, SHGC = 0.54

Cooling load $Q_{window_{\text{west}}} = CF_{window_{\text{west}}} \times A_{window_{west}} = 3499.5\ W$

Heating load $Q_{window_{west}} = \ \ HF_{window_{west}} \times A_{window_{west}} = \ 1289.2\ W$

2) The cooling load of the fixed 3.6 m² window on the South:

$$CF_{window_{\text{south}}\text{heatTrasnferPart}} = U_{window_{\text{south}}}\left(\Delta T_{cooling} - 0.46\,DR\right)$$

$$= 2.84\,(7.9 - 0.46 * 11.9) = \ 6.9\frac{W}{m^2}$$

$$PXI_{window_{\text{south}}} = E_D + E_d = 348 + 209 = 557$$

SHGC = 0.55
No internal shading so IAC = 1
FFs = 0.47

$$CF_{window_{\text{south}}\_IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 557 * 0.55 * 1 * 0.47$$

$$= 144.0\frac{W}{m^2}$$

$$CF_{window_{\text{south}}} = CF_{window_{\text{south}}\text{heatTrasnferPart}} + CF_{window_{\text{south}}\_IrradiationPart} =$$

$$6.9 + 144.0 = 150.9\frac{W}{m^2}$$

$$Q_{window_{\text{south}}} = \ CF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 150.9 * 3.6 = 543.2\ W$$

The heating load of the fixed 3.6 m² window on the South:

$$U_{window_{\text{south}}} = 2.84\frac{W}{\text{m}^2K}$$

$$HF_{window_{\text{south}}} = U_{window_{\text{south}}} \times \Delta T_{\text{heating}} = 2.84 * 24.8 = 70.4\frac{W}{m^2}$$

$$Q_{window_{\text{south}}} = \ HF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 70.4 * \ 3.6 \ = \ 253.4\ W$$

When we change the frame of the window from wooden to aluminum:

$U_{window_{\text{south}}} = \ 3.61\frac{W}{m^2}$, SHGC = 0.56

Cooling load $Q_{window_{\text{south}}} = CF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 559.4\ W$

Heating load $Q_{window_{\text{south}}} = \ HF_{window_{\text{south}}} \times A_{window_{\text{south}}} = \ 322.3\ W$

3) The cooling load of the operable 3.6 m² window on the South:

$$CF_{window_{\text{south}}\text{heatTrasnferPart}} = U_{window_{\text{south}}}\left(\Delta T_{cooling} - 0.46\ DR\right)$$

$$= 2.87\ (7.9 - 0.46 * 11.9) = \ 7.0\frac{W}{m^2}$$

$$PXI_{window_{\text{south}}} = E_D + E_d = 348 + 209 = 557$$

SHGC = 0.46
No internal shading so IAC = 1
FFs = 0.47

$$CF_{window_{\text{south}}\_IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 557\ * 0.46\ * 1\ * 0.47$$

$$= 120.4\frac{W}{m^2}$$

$$CF_{window_{\text{south}}} = CF_{window_{\text{south}}\text{heatTrasnferPart}} + CF_{window_{\text{south}}\_IrradiationPart} =$$

$$7.0 + 120.4 = 127.4\frac{W}{m^2}$$

$$Q_{window_{\text{south}}} = \ CF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 127.4 * 3.6 = 458.6\ W$$

The heating load of the operable 3.6 m² window on the South:

$$U_{window_{\text{south}}} = 2.87\frac{W}{\text{m}^2K}$$

$$HF_{window_{\text{south}}} = U_{window_{\text{south}}} \times \Delta T_{\text{heating}} = 2.87\ * 24.8 = 71.2\frac{W}{m^2}$$

$$Q_{window_{\text{south}}} = \ HF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 71.2 * \ 3.6\ = \ 256.3\ W$$

When we change the frame of the window from wooden to aluminum:

$U_{window_{\text{south}}} = \ 4.62\frac{W}{m^2}$, SHGC = 0.55

Cooling load $Q_{window_{\text{south}}} = CF_{window_{\text{south}}} \times A_{window_{\text{south}}} = 558.7\ W$

Heating load $Q_{window_{\text{south}}} = \ HF_{window_{\text{south}}} \times A_{window_{\text{south}}} = \ 412.5\ W$

4) **The total value change:**

Cooling load:

$Q_{wood\ frame} = 3352.3 + 543.2 + 458.6 = 4354.1$ W

$Q_{aluminum\ frame} = 3499.5 + 559.4 + 558.7 = 4{,}617.6$ W

$Q_{wood\ frame} - Q_{aluminum\ frame} = 4354.1 - 4{,}617.6 = -263.5$ W

Heating load:

$Q_{wood\ frame} = 1014.2 + 253.4 + 256.3 = 1{,}523.9$ W

$Q_{aluminum\ frame} = 1289.2 + 322.3 + 412.5 = 2024$ W

$Q_{wood\ frame} - Q_{aluminum\ frame} = 1{,}523.9 - 2024 = -500.1$ W