Problem 6-1

The purchased cost of a shell-and-tube heat exchanger (floating head and carbon steel tubes) with 10 m^2 (not 100 m^2) of heating surface was \$4200 in 1990. What was the 1990 purchased cost of a similar heat exchanger with 20 m^2 of heating surface if the purchased cost capacity exponent is 0.60 for surface areas ranging from 10 to 40 m^2? If the purchased cost capacity exponent is 0.81 for surface areas ranging from 40 to 200 m^2, what was the purchased cost of a heat exchanger with 100 m^2 of heating surface in 2000?

Solution:

Note the correction to the book. 100 m^2 in the first line should be 10 m^2. The first part of the problem is solved by direct application of Equation 6-2 on page 242:

$$\text{Cost of A} = \text{Cost of B} \cdot \left(\frac{\text{Area of A}}{\text{Area of B}}\right)^{n} = \$4,200 \cdot \left(\frac{20}{10}\right)^{.6} = \underline{\underline{\$6,366}}_{\text{ANS}}$$

The second part of the problem is solved by application of Equation 6-2 in steps, then scaling from 1990 to 2000 using the chemical engineering price index:

$$10\text{ m}^2 \text{ in } 1990 \;\rightarrow\; 40\text{ m}^2 \text{ in } 1990 \;\rightarrow\; 100\text{ m}^2 \text{ in } 1990 \;\rightarrow\; 100\text{ m}^2 \text{ in } 2000$$

$$\$4,200 \cdot \left(\frac{40}{10}\right)^{.6} \cdot \left(\frac{100}{40}\right)^{.81} \cdot \left(\frac{370.6}{370.9}\right) = \underline{\underline{\$20,252}}_{\text{ANS}}$$

Problem 6-2

Plot the 2000 purchased cost of the shell-and-tube heat exchanger outlined in Problem 6-1 as a function of surface area from 10 to 200 m^2. Note that the purchased cost capacity exponent is not constant over the range or surface area requested.

Solution:

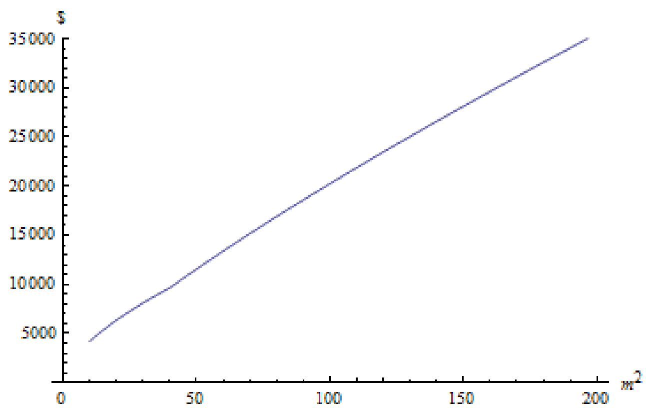
The solution in Mathematica is shown below:

In[1]:=
$$g[a\_] = 4200 * \left(\frac{a}{10}\right)^{.6} * \left(\frac{370.6}{370.9}\right);$$

$$h[a\_] = 4200 * \left(\frac{40}{10}\right)^{.6} * \left(\frac{a}{40}\right)^{.81} * \left(\frac{370.6}{370.9}\right);$$

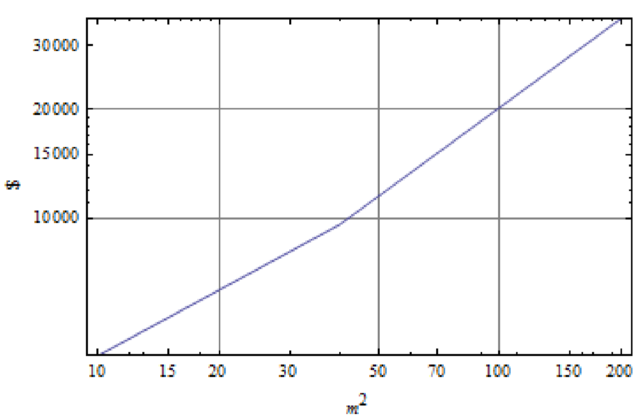
```
c[a_] = If[a < 40, g[a], h[a]];

Plot[c[a], {a, 10, 200}, PlotRange → {0, 35 000},
 AxesOrigin → {0, 0}, AxesLabel → {m², $}]
```

Out[4]=



In[5]:=
```
LogLogPlot[c[a], {a, 10, 200}, PlotRange → {0, 35 000},
 GridLines → {{20, 50, 100}, {10 000, 20 000}}, Frame → True,
 FrameLabel → {m², $}]
```

Out[5]=



A fancier book-style Log-Log plot.

Problem 6-3

The purchase and installation costs of some pieces of equipment are given as a function of weight rather than capacity. An example of this is the installed costs of large tanks. The 1990 cost for an installed aluminum tank weighing 45,000 kg was $640,000. For a size range from 10,000 to 450,000 kg, the installed cost weight exponent for aluminum tanks is 0.93. If an aluminum tank weighing 300,000 kg is required, what capital investment is needed in the year 2000?

Solution:

The simplest solution is to assume that the installed cost weight exponent can be extrapolated outside of its legitimate range down to 45,000 kg. Then scale the price directly from 45,000 to 300,000 kg, using appropriate price indices for converting the year from 1990 to 2000:

$$\$640{,}000 \cdot \left(\frac{300{,}000}{45{,}000}\right)^{.93} \cdot \left(\frac{370.6}{370.9}\right) = \underline{\underline{\$3{,}733{,}000}}_{\text{ANS}}$$

Problem 6-4

The 1990 cost for an installed 304 stainless steel tank weighing 135,000 kg was $1,100,000. The installed cost weight exponent for stainless steel tanks is 0.88 for a size range from 100,000 to 300,000 kg. What weight of installed stainless steel tank could have been obtained for the same capital investment as in Problem 6-3?

Solution:

You must compare capital costs in the same year. In this case, I decided to work in 1990 dollars, so the first step is to obtain the capital invest for Problem 6-3 in 1990:

$$\$640{,}000 \cdot \left(\frac{300{,}000}{45{,}000}\right)^{.93} = \$3{,}736{,}000$$

Then equate this dollar amount to the scaled price of the unknown vessel:

$$\$3{,}736{,}000 = 1{,}100{,}000 \cdot \left(\frac{w}{135{,}000}\right)^{.88} \Rightarrow w = \underline{\underline{542{,}000}}_{\text{ANS}} \text{ kg}$$