(By request)
Prob 2 p 344.
I look at
(*): \[ p(x) = x^T A x - 2 x^T b = (x - A^{-1} b)^T A (x - A^{-1} b) + \text{const} \]

I am not exactly sure what the author had in mind. But in high school we learn
\[ x A x^T - b x = (x - d) A (x - d) + \text{const} \]
\[ 2d = b \]
(so the constant is \(d^2\)). Let use that here, using again d
\[ x^T A x - 2 x^T b = (x - d) A (x - d) + d^T A d \]
\[ = x^T A x - 2 x^T A d + d^T A d - d^T A d \]
So we need to agree on the formula (*) that
\[ A d = b \]
or\[ d = A^{-1} b \]
That explains why in (*) we have \((x - A^{-1} b)^T A (x - A^{-1} b)\).
Then
\[ -d^T A d = -(A^{-1} b)^T A (A^{-1} b) \]
\[ = -b^T A^{-1} A A^{-1} b \]
\[ = -b^T A b \]
(recall \(A^T = A(A^T A)^{-1} A\))

So this means that
\[ x^T A x - 2 x^T b = (x - A^{-1} b)^T A (x - A^{-1} b) - b^T A b, \]
Thus: if we solve \(A x = b\), we have that
\[ p(x) = -b^T A b = \text{Pmin} \]
(I call 2P what he calls \(P\))

This seems to be what the author had in mind.