From equation (3.52) and $t+s = t_b - t_a$

$$K(b,a) = F(t+s)\exp\left(\frac{im(x_b - x_a)^2}{2\hbar(t+s)}\right) \tag{1}$$

From equation (2.31)

$$K(b,a) = \int_{-\infty}^{\infty} K(b,c)K(c,a)\,dx_c$$

Hence

$$K(b,a) = F(t)F(s)\int_{-\infty}^{\infty} \exp\left(\frac{im(x_b - x_c)^2}{2\hbar t}\right)\exp\left(\frac{im(x_c - x_a)^2}{2\hbar s}\right)\,dx_c$$

Solve the integral.

$$K(b,a) = F(t)F(s)\left(\frac{2\pi i\hbar ts}{m(t+s)}\right)^{1/2}\exp\left(\frac{im(x_b - x_a)^2}{2\hbar(t+s)}\right) \tag{2}$$

Equating (1) with (2) causes the exponentials to cancel leaving

$$F(t+s) = F(t)F(s)\left(\frac{2\pi i\hbar ts}{m(t+s)}\right)^{1/2} \tag{3}$$

Show that if

$$F(t) = \left(\frac{m}{2\pi i\hbar t}\right)^{1/2} f(t)$$

then the new function $f(t)$ must satisfy

$$f(t+s) = f(t)f(s)$$

By substitution

$$F(t+s) = \left(\frac{m}{2\pi i\hbar(t+s)}\right)^{1/2} f(t+s)$$

and

$$F(t)F(s) = \left(\frac{m}{2\pi i\hbar t}\right)^{1/2}\left(\frac{m}{2\pi i\hbar s}\right)^{1/2} f(t)f(s)$$

Then by (3) we have

$$\left(\frac{m}{2\pi i\hbar(t+s)}\right)^{1/2} f(t+s) = \left(\frac{m}{2\pi i\hbar t}\right)^{1/2}\left(\frac{m}{2\pi i\hbar s}\right)^{1/2} f(t)f(s)\left(\frac{2\pi i\hbar ts}{m(t+s)}\right)^{1/2}$$

The coefficients cancel leaving

$$f(t+s) = f(t)f(s) \tag{4}$$