I) Solve Problems: **4.8, 4.9, 4.10, 4.18, 4.20, 4.21** on Pages **171-172** of the textbook (Auletta, Fortunato & Parisi, Cambridge University Press, 2009).

II) Solve the following problems.

1. Consider a free particle of mass m that moves on the real line $\mathbb{R}$. Suppose that at time $t = 0$ the particle is in state described by the position wave function $\psi(x, 0) := e^{-\frac{x^2}{2\sigma^2}+i\frac{x}{\alpha}}$ where σ and α are positive real quantities with the dimension of length.

a) Use the formula for the free-particle propagator $K(x, t; x_0, t_0)$ to compute the position wave function $\psi(x, t)$ of the particle at time $t > 0$.

b) Find the probability ρ and current density $\vec{J}$ of the localization of this particle in space for $t \geq 0$.

c) Find the uncertainty in the position Δx of this particle for $t \geq 0$.

d) Find the uncertainty in the momentum Δp of this particle for $t \geq 0$.

e) Calculate $\Delta x \Delta p$ for $t \geq 0$.

2. Calculate the uncertainty in the position and momentum of a simple harmonic oscillator of mass m and angular frequency ω that is in a coherent state, i.e., in an eigenstate of the annihilation operator $\hat{a}$.