

## Physics 223c Problem Set 1. (due 4/10)

### Problem 1 (60)

Suppose a certain substance with diffusivity  $D$  is continuously emitted from a point source at the origin with a rate  $\Gamma$  and decays spontaneously with the rate  $\gamma$ . The whole process happens in 2D.

- a) Write down an equation governing the spatio-temporal distribution of concentration of this substance,  $c(r, t)$ .
- b) Solve the equation for the long time, behavior  $c(r, t \lim \infty)$ .
- c) Determine asymptotic behavior near and far from the source.

### Problem 2 (40)

Derive Langevin equation description for an electric charge,  $Q$ , on a capacitor  $C$  hooked up to a resistor,  $R$ , all in thermal equilibrium at temperature  $T$ . Use the fluctuation-dissipation theorem type argument to determine the thermal noise in the resistor (Johnson noise):  $\langle I(t)I(0) \rangle$ , where  $I(t)$  is the current at time  $t$ . (Hint: In thermal equilibrium, average charge fluctuations on the capacitor,  $\langle Q^2 \rangle = \frac{1}{2}k_B T$ ).