1:

let $d = \sqrt{B_1^2(t) + B_2^2(t)}$, let $y = d^2$, we have $\frac{Y}{t} = z_1^2 + z_2^2 \sim \chi_2^2$, where z_1, z_2 are standard normal distribution.

$$\mathbb{P}(D < x) = \mathbb{P}(Y < x^2) = \mathbb{P}(\frac{Y}{t} < \frac{x^2}{t}) = F_{\chi_2^2}(\frac{x^2}{t})$$

$$f_d(x) = f_{\chi_2^2}(\frac{x^2}{t})\frac{2x}{t} = \frac{x}{t}e^{-\frac{1}{2}\frac{x^2}{t}}\mathbb{I}_{x>0}$$

4:

$$\begin{aligned}\mathbb{P}(B^*(t) \geq a, B(t) \leq x) &= \mathbb{P}(B(t) \leq x) - \mathbb{P}(B^*(t) < a, B(t) \leq x)\\ &= \mathbb{P}(B(t) \leq x) - \mathbb{P}(B^*(t) < a)\\ &= \mathbb{P}(B(t) \leq x) - \mathbb{P}(\tau_a > t)\end{aligned}$$

we apply reflection principal

$$\begin{aligned}\mathbb{P}(\tau_a > t) &= 1 - \mathbb{P}(\tau_a < t)\\ &= 1 - 2\mathbb{P}(B(t) > a)\end{aligned}$$

$$\begin{aligned}\mathbb{P}(B^*(t) \geq a, B(t) \leq x) &= \mathbb{P}(B(t) \leq x) - 1 + 2\mathbb{P}(B(t) > a)\\ &= 2N(-\frac{a}{\sqrt{t}}) - N(-\frac{x}{\sqrt{t}})\end{aligned}$$

where $N(\cdot)$ is culmulative function of standard normal distribution.