

# Evans PDE Solutions for Ch2 and Ch3

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## SOLUTIONS OF CHAPTER 2

1. Consider the function  $z : \mathbb{R} \rightarrow \mathbb{R}$  for fixed  $x \in \mathbb{R}^n$  and  $t \in (0, \infty)$

$$z(s) = u(x + bs, t + s)e^{cs}$$

Then

$$z'(s) := \frac{\partial z}{\partial s} = e^{cs}(b \cdot D_x u(x + sb, t + s) + u_s(x + sb, t + s) + cu(x + sb, t + s)) = 0$$

by the condition given by the problem. Therefore,  $z$  is a constant function with respect to  $s$ . Finally, by using the fact that  $u = g$  on  $\mathbb{R}^n \times \{t = 0\}$ , we conclude that

$$u(x, t) = z(0) = z(-t) = u(x - tb, 0)e^{-ct} = g(x - tb)e^{-ct}$$

2. Let  $O = (a_{ij})$  and  $\phi(x) = O \cdot x$ . Then it's clear that  $D\phi(x) = O$ . Since  $v$  is defined to be  $v(x) = u(O \cdot x) = (u \circ \phi)(x)$ , we calculate

$$Dv(x) = Du(\phi(x)) \cdot D\phi(x) = Du(O \cdot x) \cdot O$$

Then  $v_{x_i}(x) = \sum_{j=1}^n u_{x_j}(\phi(x))a_{ji}$ . Note that by the same calculations, we have

$$D(u_{x_j} \circ \phi)(x) = Du_{x_j}(\phi(x)) \cdot O$$

Therefore

$$v_{x_i x_i}(x) = \frac{\partial}{\partial x_i} v_{x_i}(x) = \sum_{j=1}^n \frac{\partial}{\partial x_i} u_{x_j}(\phi(x))a_{ji} = \sum_{j=1}^n a_{ji} \left( \sum_{k=1}^n u_{x_j x_k}(\phi(x))a_{ki} \right) = \sum_{j,k=1}^n a_{ji} a_{ki} u_{x_j x_k}(\phi(x))$$

The laplacian of  $v$  is

$$\Delta v(x) = \sum_{i=1}^n v_{x_i x_i}(x) = \sum_{i=1}^n \left( \sum_{j,k=1}^n a_{ji} a_{ki} u_{x_j x_k}(\phi(x)) \right) = \sum_{j,k=1}^n (u_{x_j x_k}(\phi(x)) \sum_{i=1}^n a_{ji} a_{ki})$$

Since  $O$  is an orthogonal matrix,

$$\sum_{i=1}^n a_{ji} a_{ki} = \begin{cases} 1 & \text{if } j = k \\ 0 & \text{otherwise} \end{cases}$$

Lastly, we conclude our proof with

$$\Delta v(x) = \sum_{j=1}^n (u_{x_j x_j}(\phi(x))) = \Delta u(\phi(x)) = 0$$

# Evans Pde Solution Manual

**R Bogdan**



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