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4. The wave equation

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Problem Set B due Aug 18, 2021 20:30 IST Completed

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Problem 4

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Consider the (partial differential) equation $f_{tt} - v^2 f_{xx} = 0$. This is known as a **wave equation** .

Which of the following functions satisfy this partial differential equation? (Choose all that apply.)

- [x] $\sin(x+vt)$
- [x] $\sin(x-vt)$
- [x] $\sin(x+vt) + \sin(x-vt)$
- [x] $\sin(x)\cos(vt)$
- [x] $f(x-vt)$ for an arbitrary (differentiable) function f
- [x] $f(x+vt)$ for an arbitrary (differentiable) function f

Solution:

Note that $f(x \pm vt)$ satisfies

$$f_{xx} = f''(x \pm vt) \tag{3.153}$$
$$f_{tt} = v^2 f''(x \pm vt) \tag{3.154}$$
$$\longrightarrow \quad f_{tt} - v^2 f_{xx} = 0 \tag{3.155}$$

Similarly, if we take sums of any functions of this type, they will also satisfy the differential equation. The only one we need to check is $\sin(x)\cos(vt)$.

$$\frac{\partial^2}{\partial x^2}\sin(x)\cos(vt) = -\sin(x)\cos(vt) \tag{3.156}$$
$$\frac{\partial^2}{\partial t^2}\sin(x)\cos(vt) = -v^2\sin(x)\cos(vt) \tag{3.157}$$
$$\longrightarrow \quad f_{tt} - v^2 f_{xx} = 0 \tag{3.158}$$

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Answers are displayed within the problem

4. The wave equation

Topic: Unit 2: Geometry of Derivatives / 4. The wave equation

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Question on placement of v^2 coefficient
Shouldn't the v^2 be in front of the f_tt, not f_xx
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ftt,fxx?
What does ftt and fxx means?
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