

Physics 89 - Introduction to Mathematical Physics

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January 17, 2023

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1 Difference between Mathematics and Physics

Example 1 - Electrostatics

Math Question

$$x + \frac{x^2}{2} + \frac{x^3}{3} + \frac{x^4}{4} + \dots = ?$$

Math Solution

$$x + \frac{x^2}{2} + \frac{x^3}{3} + \dots = -\log(1-x), \quad \text{for } -1 \leq x \leq 1$$

So,

$$-1 + \frac{1}{2} - \frac{1}{3} + \frac{1}{4} - \frac{1}{5} + \dots = -\log(2)$$

Example 2 - Diffusion

$f(x, y, z, t)$ = density of diffusing material at time t

Let there exist a cube containing moles

$$\frac{\partial f}{\partial t} = D \left(\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} \right)$$

where D is the *diffusion coefficient*, and the diffusion equation describes how f evolves with time

Math Question

Solve

$$\frac{\partial f}{\partial t} = D \left(\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} \right)$$

given initial condition

$f(x, y, z, 0)$ = concentrated lump at the origin

Math Solution

$$f(x, y, z, t) = \frac{N}{(4\pi Dt)^{3/2}} e^{-\frac{x^2+y^2+z^2}{4Dt}}$$

where N is the number of moles released