

Non Linear Partial Differential Equation

Theorem If $F(x, y, z, p, q) = 0$ be a nonlinear partial differential equation then the Charpit's auxiliary

equations are:
$$\frac{\frac{dp}{\frac{\partial F}{\partial x} + p \frac{\partial F}{\partial z}}}{\frac{\partial F}{\partial y} + q \frac{\partial F}{\partial z}} = \frac{\frac{dq}{\frac{\partial F}{\partial y} + q \frac{\partial F}{\partial z}}}{-p \frac{\partial F}{\partial p} - q \frac{\partial F}{\partial q}} = \frac{\frac{dz}{-p \frac{\partial F}{\partial p} - q \frac{\partial F}{\partial q}}}{-\frac{\partial F}{\partial p}} = \frac{dx}{-\frac{\partial F}{\partial p}} = \frac{dy}{-\frac{\partial F}{\partial q}}$$

or,
$$\frac{dp}{F_x + pF_z} = \frac{dq}{F_y + qF_z} = \frac{dz}{-pF_p - qF_q} = \frac{dx}{-F_p} = \frac{dy}{-F_q}$$

Problem 1: Find the complete integral of the given partial differential equation by Charpit's method

$$p^2 - y^2q = y^2 - x^2$$

Solution Given that, $p^2 - y^2q = y^2 - x^2$

Let, $F(x, y, z, p, q) = p^2 - y^2q - y^2 + x^2 = 0$ (i)

We know the Charpit's auxiliary equations are

$$\frac{\frac{dp}{\frac{\partial F}{\partial x} + p \frac{\partial F}{\partial z}}}{\frac{\partial F}{\partial y} + q \frac{\partial F}{\partial z}} = \frac{\frac{dq}{\frac{\partial F}{\partial y} + q \frac{\partial F}{\partial z}}}{-p \frac{\partial F}{\partial p} - q \frac{\partial F}{\partial q}} = \frac{\frac{dz}{-p \frac{\partial F}{\partial p} - q \frac{\partial F}{\partial q}}}{-\frac{\partial F}{\partial p}} = \frac{dx}{-\frac{\partial F}{\partial p}} = \frac{dy}{-\frac{\partial F}{\partial q}}$$

or,
$$\frac{dp}{2x+0} = \frac{dq}{-2yq-2y+0} = \frac{dz}{-2p^2+y^2q} = \frac{dx}{-2p} = \frac{dy}{y^2}$$

From 1st and 4th ratio, we get,

$$\frac{dp}{2x} = \frac{dx}{-2p}$$

or, $pdp + xdx = 0$

or, $p^2 + x^2 = c_1$ (ii) [By integrating]

Now, solving (i) and (ii) we get, $c_1 - y^2q - y^2 = 0$

or, $q = \frac{c_1 - y^2}{y^2} = \frac{c_1}{y^2} - 1$

and $p = \sqrt{c_1 - x^2}$

We know, $dz = \frac{\partial z}{\partial x} dx + \frac{\partial z}{\partial y} dy$

or, $dz = p dx + q dy$

or, $dz = \sqrt{c_1 - x^2} dx + \left(\frac{c_1}{y^2} - 1\right) dy$

or, $\int dz = \int \sqrt{c_1 - x^2} dx + \int \left(\frac{c_1}{y^2} - 1\right) dy$

or, $z = \frac{\sqrt{c_1 - x^2}}{2c_1} + \frac{c_1}{2} \sin^{-1}\left(\frac{x}{\sqrt{c_1}}\right) - \frac{c_1}{y} - y + k$ [By integrating]

which is the required complete integral/ Solution of (i).

Nonlinear Partial Differential Equations

SJ Ball



Nonlinear Partial Differential Equations:

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