

# 1 Introduction to Differential Equations

## Exercises 1.1

1. Second-order; linear.
2. Third-order; nonlinear because of  $(dy/dx)^3$ .
3. The differential equation is first-order. Writing it in the form  $x(dy/dx) + y^2 = 1$ , we see that it is nonlinear in  $y$  because of  $y^2$ . However, writing it in the form  $(y^2 - 1)(dy/dx) + x = 0$ , we see that it is linear in  $x$ .
4. The differential equation is first-order. Writing it in the form  $x(dy/dx) + (1 + u) = u^n$  we see that it is linear in  $x$ . However, writing it in the form  $(x + u - u^n)(dy/dx) + u = 0$ , we see that it is nonlinear in  $u$ .
5. Fourth-order; linear.
6. Second-order; nonlinear because of  $\cos(x + u)$ .
7. Second-order; nonlinear because of  $\sqrt{1 + (dy/dx)^2}$ .
8. Second-order; nonlinear because of  $1/y^3$ .
9. Third-order; linear.
10. Second-order; nonlinear because of  $x^2$ .
11. From  $y = e^{-t/2}$  we obtain  $y' = -\frac{1}{2}e^{-t/2}$ . Then  $2y' + y = -e^{-t/2} + e^{-t/2} = 0$ .
12. From  $y = \frac{1}{2} - \frac{1}{2}e^{-2t}$  we obtain  $dy/dt = 2e^{-2t}$ , so that

$$\frac{dy}{dt} + 2ty = 2te^{-2t} = 2t\left(\frac{0}{2} - \frac{0}{2}e^{-2t}\right) = 2t.$$

13. From  $y = e^{2t} \cos 2t$  we obtain  $y' = 2e^{2t} \cos 2t - 2e^{2t} \sin 2t$  and  $y'' = 2e^{2t} \cos 2t - 12e^{2t} \sin 2t$ , so that  $y'' - 4y' + 4y = 0$ .
14. From  $y = -\cos x$  (we  $x + \tan x$ ) we obtain  $y' = -1 + \sin x$  (we  $x + \tan x$ ) and  $y'' = \tan x + \sec x$  (we  $x + \tan x$ ). Then  $y'' + y = \tan x$ .
15. Writing  $\ln(2X - 1) = \ln(X - 1) + t$  and differentiating implicitly we obtain

$$\begin{aligned} \frac{2}{2X-1} \frac{dX}{dt} &= \frac{1}{X-1} \frac{dX}{dt} + 1 \\ \left( \frac{2}{2X-1} - \frac{1}{X-1} \right) \frac{dX}{dt} &= 1 \\ \frac{2X-2-(2X-1)}{(2X-1)(X-1)} \frac{dX}{dt} &= 1 \\ \frac{dX}{dt} &= -(2X-1)(X-1) = (X-1)(1-2X). \end{aligned}$$

Exponentiating both sides of the implicit solution we obtain

$$\frac{2X-1}{X-1} = e^t \implies 2X-1 = Xe^t - e^t \implies (e^t-1) = (e^t-2)X \implies X = \frac{e^t-1}{e^t-2}.$$

Solving  $e^t - 2 = 0$  we get  $t = \ln 2$ . Thus, the solution is defined on  $(-\infty, \ln 2)$  or on  $(\ln 2, \infty)$ . The graph of the solution defined on  $(-\infty, \ln 2)$  is dashed, and the graph of the solution defined on  $(\ln 2, \infty)$  is solid.



# Kannur University Engineering Mathematics Solution Manual

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