1016 Chapter 17 Second-Order Differential Equations

$$y(1) = e \Rightarrow c_1 e + c_2 e = e, y'(1) = 0 \Rightarrow c_1 e + 2c_2 e + e = 0 \Rightarrow c_1 e + 2c_2 e = -e \Rightarrow c_1 + c_2 = 1, c_1 + 2c_2 = -1 \Rightarrow c_1 = 3, c_2 = -2 \Rightarrow y = 3e^x - 2xe^x + xe^x \ln x$$

59.
$$x^2y'' + 2xy' - 2y = x^2$$
, $y_1 = x^{-2}$, $y_2 = x$

$$\Rightarrow v_1' = \frac{\begin{vmatrix} 0 & x \\ \frac{5}{2} & 1 \end{vmatrix}}{\begin{vmatrix} -2x^{-2} & 1 \\ -2x^{-2} & 1 \end{vmatrix}} = \frac{-x}{5x^2} = -\frac{1}{3}x^3 \text{ and } v_2' = \frac{\begin{vmatrix} x^{-1} & 0 \\ -2x^{-2} & 5 \end{vmatrix}}{\begin{vmatrix} x^{-1} & -x \\ -2x^{-2} & 1 \end{vmatrix}} = \frac{x^{-1}}{5x} = \frac{1}{3}$$

$$\Rightarrow v_1 = \int -\frac{1}{3}x^3 dx = -\frac{1}{3}x^4 \text{ and } v_2 = \int \frac{1}{3}dx = \frac{1}{3}x \Rightarrow y_2 = (-\frac{1}{3}x^4)(x^{-2}) + (\frac{1}{3}x)(x) = \frac{1}{3}x^2$$

$$\begin{aligned} &60. \ \ x^2y'' + xy' - y = x, \ y_1 = x^{-1}, \ y_2 = x \\ &\Rightarrow v_1' = \frac{\left| \begin{smallmatrix} 0 & x \\ -1 & 1 \end{smallmatrix} \right|}{\left| \begin{smallmatrix} x - 1 & x \\ -x & 1 \end{smallmatrix} \right|} = \frac{-1}{2x} \ \text{and} \ v_2' = \frac{\left| \begin{smallmatrix} x - 1 & 0 \\ -x - 1 & 2 \end{smallmatrix} \right|}{\left| \begin{smallmatrix} x - 1 & 0 \\ -x & 1 \end{smallmatrix} \right|} = \frac{1}{2x} x^{-1} \\ &\Rightarrow v_1 = \int -\frac{1}{2}x \, dx = -\frac{1}{4}x^2 \ \text{and} \ v_2 = \int \frac{1}{2}x^{-1} \, dx = \frac{1}{2}\ln|x| \Rightarrow y_p = \left(-\frac{1}{4}x^2\right)(x^{-1}) + \left(\frac{1}{2}\ln|x|\right)(x) = -\frac{1}{4}x + \frac{1}{2}x\ln|x| \end{aligned}$$

17.3 APPLICATIONS

$$1. \quad mg=16 \Rightarrow m=\frac{36}{32}; \ k=1; \ \delta=1 \Rightarrow \frac{16}{32} \frac{dy}{dx} + 1 \frac{dy}{dx} + 1 y=0 \Rightarrow \frac{1}{2} \frac{dy}{dx} + \frac{dy}{dx} + y=0, \ y(0)=2, \ y'(0)=2$$

2.
$$mg = 8 lb \Rightarrow m = \frac{4}{52}; 8 = k \cdot 4 \Rightarrow k = 2; \delta = 1.5 \Rightarrow \frac{4}{52} \stackrel{\triangle}{B} + 1.5 \stackrel{\triangle}{B} + 2 y = 0 \Rightarrow \frac{1}{4} \stackrel{\triangle}{B} + \frac{3}{2} \stackrel{\triangle}{B} + 2 y = 0, y(0) = -2, y'(0) = 3$$

3.
$$20 = k \cdot \frac{1}{2} \Rightarrow k = 40$$
; $w = 25$ lb $\Rightarrow m = \frac{25}{32}$; $\delta = 0 \Rightarrow \frac{25}{32} \frac{dy}{dx} + 0 \cdot \frac{dy}{dx} + 40y = 0$. If $w = 25$ lb, it stretches the spring $25 = 40x \Rightarrow x = \frac{5}{8}$ ft \Rightarrow spring is now stretched $\frac{6+5}{12} - \frac{5}{8} = \frac{7}{24}$ ft below equilibrium $\Rightarrow y(0) = \frac{7}{24}$; initial velocity is $v_0 \stackrel{\text{in}}{\Rightarrow} = \frac{7}{12} \stackrel{\text{ft}}{\Rightarrow} \Rightarrow y'(0) = \frac{7}{12}$. Thus we have $\frac{25}{32} \stackrel{\text{ft}}{\Rightarrow} = 40y = 0$, $y(0) = \frac{7}{24}$, $y'(0) = \frac{7}{12}$.

4.
$$\mathbf{w} = 10 \text{ lb} \Rightarrow \mathbf{m} = \frac{10}{32}; \ 10 = \mathbf{k} \cdot \left(\frac{2}{12}\right) \Rightarrow \mathbf{k} = 60 \frac{36}{61}; \delta = \frac{20}{\sqrt{32}} = \frac{20}{\sqrt{32}} \Rightarrow \frac{10}{32} \frac{12}{32} + \frac{20}{\sqrt{32}} \frac{12}{32} + 60 \mathbf{y} = 0$$

$$\Rightarrow \frac{12}{32} \frac{12}{32} + \frac{2}{32} \frac{12}{32} + 60 \mathbf{y} = 0, \mathbf{y}(0) = \frac{1}{4}, \mathbf{y}'(0) = 0$$

5.
$$E(t) = 20\cos t$$
; $R^{\frac{4}{20}} = 4\frac{45}{5}$; $\frac{1}{6}q = 10q$; $L^{\frac{4}{20}} = 2\frac{67}{5} \Rightarrow 2\frac{67}{5} + 4\frac{49}{5} + 10q = 20\cos t$, $q(0) = 2$, $q'(0) = 3$

6.
$$L = 2$$
, $R = 12$, $C = \frac{1}{4}$, $E(t) = 300 \Rightarrow 2\frac{45}{2} + 12\frac{44}{2} + 16q = 300$, $q(0) = 0$, $q'(0) = 0$

7.
$$mg = 16 \Rightarrow m = \frac{16}{32}$$
; $k = 1$; resistance = velocity $\Rightarrow \delta = 1 \Rightarrow \frac{1}{2}\frac{d^3r}{dr} + 1\frac{dr}{dr} + 1y = 0$, $y(0) = 2$, $y'(0) = 2$ $\Rightarrow \frac{1}{2}r^2 + r + 1 = 0 \Rightarrow r^2 + 2r + 2 = 0 \Rightarrow r = \frac{-2\pi\sqrt{2^2 - 4(0)(2)}}{2(0)} = -1 \pm i \Rightarrow y = e^{-i}(c_0\cos t + c_2\sin t)$. $\Rightarrow y' = e^{-i}(-c_1\sin t + c_2\cos t) - e^{-i}(c_1\cos t + c_2\sin t)$; $y(0) = 2 \Rightarrow c_1 = 2$; $y'(0) = 2 \Rightarrow c_2 - c_1 = 2 \Rightarrow c_2 = 4$ $\Rightarrow y(t) = e^{-i}(2\cos t + 4\sin t)$. At $t = \pi$, $y = e^{-i\pi}(2\cos \pi + 4\sin \pi) = -2e^{-i\pi} \approx -0.0864 \Rightarrow 0.0864$ ft above equilibrium.

8.
$$w = 8 \Rightarrow m = \frac{8}{32}$$
; $8 = k \cdot 4 \Rightarrow k = 2$; resistance $= 1.5 \text{ v} \Rightarrow \delta = 1.5 \Rightarrow \frac{1}{4} \frac{67}{62} + 1.5 \frac{67}{4} + 2y = 0$, $y(0) = -2$, $y'(0) = 3 \Rightarrow \frac{1}{4}r^2 + 1.5r + 2 = 0 \Rightarrow r^2 + 6r + 8 = 0 \Rightarrow (r + 4)(r + 2) \Rightarrow r = -4 \text{ or } r = -2 \Rightarrow y = c_1e^{-4c} + c_2e^{-2t} \Rightarrow y' = -4c_1e^{-4c} - 2c_2e^{-2t}$; $y(0) = -2 \Rightarrow c_1 + c_2 = -2$; $\Rightarrow y'(0) = 3 \Rightarrow -4c_1 - 2c_2 = 3 \Rightarrow c_1 = \frac{1}{2}$, $c_2 = -\frac{5}{2} \Rightarrow y(t) = \frac{1}{2}e^{-4t} - \frac{5}{2}e^{-2t}$. At $t = 2$, $y = \frac{1}{2}e^{-4t} - \frac{5}{2}e^{-2t} \approx -0.0456 \Rightarrow 0.0456$ ft above equilibrium.

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