Solve:

1) At 2 pm, water began leaking from a broken pipe at a rate of $3t + 1$ gal/hour where t is the number of hours after 2 pm. How much water is lost between 3 pm and 10 pm?

$$\int_1^8 3t+1\,dt = \frac{3}{2}t^2+t\Big|_1^8$$

$$= 104 - 2.5 = \boxed{101.5 \text{ gallons}}$$

2) At 4 am, water began leaking from a bathtub at a rate of $3t + 4$ gal/hour where t is the number of hours after 4 am. How much water is lost between 7 am and 10 am?

$$\int_3^6 3t+4\,dt = \frac{3}{2}t^2+4t\Big|_3^6$$

$$= 78 - 25.5 = \boxed{52.5 \text{ gallons}}$$

3) At 4 pm, water began leaking from a water tower at a rate of $3t^2 + 5t + 2$ gal/hour where t is the number of hours after 4 pm. How much water is lost between 6 pm and 9 pm?

$$\int_2^5 3t^2+5t+2\,dt = t^3+\frac{5}{2}t^2+2t\Big|_2^5$$

$$= 197.5 - 22 = \boxed{175.5 \text{ gallons}}$$

4) $C(x)$ represents the cost of producing x CDs (in units of 1000). $C'(x) = 500x^2 + 4000x + 10000$ (dollars per thousand CDs). Find the cost of producing 8,000 CDs assuming that $C(0) = \$25{,}000$.

$$\int 500x^2+4000x+10000\,dx$$

$$C(x) = \frac{500}{3}x^3+2000x^2+10{,}000x+C$$

$$25{,}000 = 0 + C$$

$$C = 25{,}000$$

$$C(x) = \frac{500}{3}x^3+2000x^2+10{,}000x+25{,}000$$

$$\boxed{C(8) = \$318{,}333.33}$$

5) The marginal cost of producing x DVDs (in units of 1000) is given by $C(x)$. $C'(x) = 400x^2 + 1000x + 20000$ (dollars per thousand DVDs). Find the cost of producing 2,000 DVDs assuming that $C(0) = \$35{,}000$.

$$\int 400x^2+1000x+20{,}000\,dx$$

$$C(x) = \frac{400}{3}x^3+500x^2+20{,}000x+C$$

$$35{,}000 = C$$

$$C(x) = \frac{400}{3}x^3+500x^2+20{,}000x+35{,}000$$

$$\boxed{C(2) = \$78{,}066.67}$$

6) $C(x)$ represents the cost of producing x DVDs (in units of 1000). $C'(x) = 4000x + 10000$ (dollars per thousand DVDs). Find the cost of producing 11,000 DVDs assuming that $C(0) = \$24{,}000$.

$$\int 4000x+10{,}000\,dx$$

$$C(x) = 2000x^2+10{,}000x+C$$

$$C = 24{,}000$$

$$C(x) = 2000x^2+10{,}000x+24{,}000$$

$$\boxed{C(11) = \$376{,}000}$$

7) The velocity of a particle is $v(t) = 5t + 3$ ft/s. Find the displacement between $t = 4$ and $t = 12$ seconds.

$$\int_4^{12} 5t+3\,dt$$

$$= \frac{5}{2}t^2+3t\Big|_4^{12}$$

$$= 396 - 52 = \boxed{344 \text{ ft.}}$$

8) The velocity of a particle is $v(t) = t^2 - 22t + 112$ ft/s. Find the total distance traveled between $t = 5$ and $t = 9$ seconds.

$$\left|\int_5^8 t^2-22t+112\,dt\right| + \left|\int_8^9 t^2-22t+112\,dt\right|$$

$$\frac{t^3}{3}-11t^2+112t$$

$$\left|\frac{1088}{3}-\frac{980}{3}\right| + \left|360-\frac{1088}{3}\right|$$

$$36 + \frac{8}{3}$$

$$\boxed{\frac{116}{3}}$$