

### 8.3 example SOLUTIONS

1. The volume of water in an above-ground pool is 45 000 L. A pump can move water at a rate of

$$r_{\text{pump}}(t) = \frac{20(35 + \log_{10}(\frac{t+1}{100}))}{\frac{t}{100} + 3} \text{ L/min}$$

where  $t$  is time measured in minutes.

- (a) How much water would be in the pool if water is pumped in for 30 minutes?

**Solution:**

$$45000 + \int_0^{30} r_{\text{pump}}(t) dt \approx 51499.8 \text{ L}$$

- (b) How much water would be in the pool if water is pumped out for 30 minutes?

**Solution:**

$$45000 - \int_0^{30} r_{\text{pump}}(t) dt \approx 38500.2 \text{ L}$$

- (c) Suppose the pump is being used to move water into the pool. Suppose further that there is a leak in the pool, where water is leaking at a rate of

$$r_{\text{leak}}(t) = 225 - t \sin \frac{t}{11}$$

On the interval  $t \in [0, 30]$ :

- (i) When is the pool at its fullest?
- (ii) When is the pool at its emptiest?
- (iii) Is the volume of the pool increasing or decreasing at  $t = 30$ ?

**Solution:** We have  $V(t) = 45000 + \int_0^t r_{\text{pump}}(x) dx - \int_0^t r_{\text{leak}}(x) dx$ . Then  $V'(t) = r_{\text{pump}}(t) - r_{\text{leak}}(t)$ , which has critical points  $t \approx 6.964, 28.399$ . We apply the candidates test on the critical points and endpoints:

$t$	$V(t)$
0	45000
6.964	45015.206
28.399	44896.398
30	44899.415

- (i) The pool at its fullest at  $\approx 6.964$  minutes.

- (ii) The pool at its emptiest at  $\approx 28.399$  minutes.

- (iii)  $V'(30) = r_{\text{pump}}(30) - r_{\text{leak}}(30) > 0$ , so the volume is increasing at 30 minutes.