1. [10 points] Unfortunately, Sebastian left the King’s castle but never made it to Adam’s manor because the brakes on his car were sabotaged. Sebastian was driving on a straight road between the King’s castle and Adam’s manor when he found himself unable to brake and racing down a hill. Let \( v(t) \) be Sebastian’s velocity (in kilometers per minute) \( t \) minutes after he left the King’s castle. Note that \( v(t) \) is positive when Sebastian is traveling towards Adam’s manor. Sebastian suspected he was being followed so he occasionally backtracked. Sebastian crashed 30 minutes into his journey. A graph of \( v(t) \) is given below.

![Graph of \( v(t) \)]

a. [3 points] How far from the King’s castle was Sebastian 12 minutes into his journey? **Include units.**

**Solution:** Since Sebastian initially started at the King’s castle, his distance from it after 12 minutes is given by \( \int_{0}^{12} v(t) \, dt \). To calculate this we need to calculate the signed area between the graph of \( v(t) \) and the \( t \)-axis. Therefore,

\[
\int_{0}^{12} v(t) \, dt = (0.5)(8)(0.75) - (0.5)(4)(0.25) = 2.5 \text{ km}.
\]

(Note that 0.5 is the area of each box in the graph.)

**Answer:** 2.5 km

b. [2 points] What was Sebastian’s average velocity during the first 12 minutes of his journey?

**Solution:** Sebastian’s average velocity during the first 12 minutes is given by the equation

\[
\frac{1}{12} \int_{0}^{12} v(t) \, dt = \frac{2.5}{12}.
\]

**Answer:** \( \frac{2.5}{12} \text{ km/min} \)

c. [2 points] Of the four times below, circle the one at which Sebastian’s acceleration was the greatest (i.e. most positive).

\( t = 6 \quad t = 13 \quad t = 20 \quad t = 27 \)

\( \boxed{t = 27} \)

d. [3 points] In the interval \( 0 \leq t \leq 30 \) when was Sebastian the closest to the King’s castle? When was he the furthest from the King’s castle?

**Answer:** Sebastian was the closest to the King’s castle at \( t = 0 \).

Sebastian was the furthest from the King’s castle at \( t = 20 \).