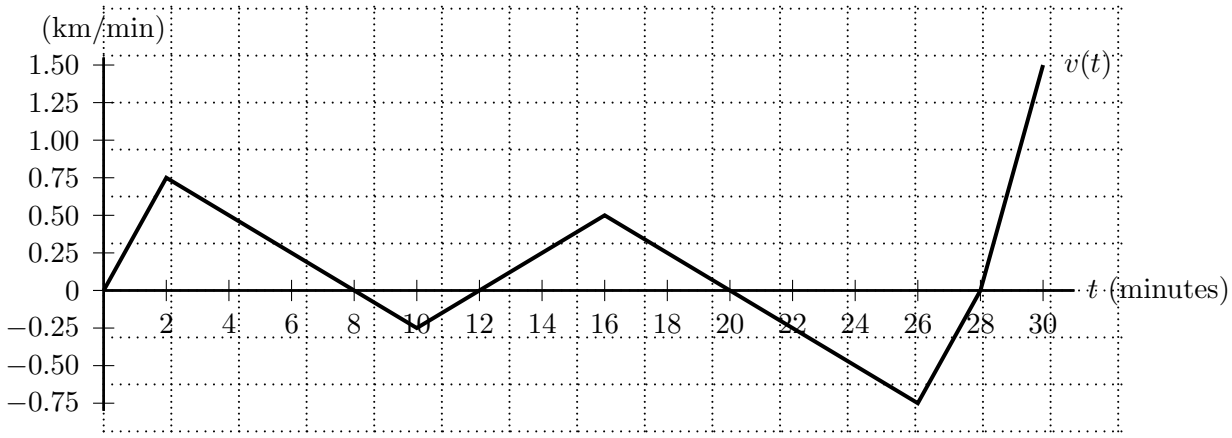
1. [10 points] Unfortunately, Sebastian left the King's castle but never made it to Adam's manor because the brakes on his car were sabotaged. Sebastian was driving on a straight road between the King's castle and Adam's manor when he found himself unable to brake and racing down a hill. Let $v(t)$ be 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.



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

$$frac112 \int_0^{12} v(t)\,dt = \frac{2.5}{12}.$$

Answer: $\frac{2.5}{12}$ **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).

$t = 6$ $t = 13$ $t = 20$ $\boxed{t = 27}$

d. [3 points] In the interval $0 \le t \le 30$ 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**.