# Velocity-Time Graphs

| | $\vec{d}$–$t$ graphs | $\vec{v}$–$t$ graphs | Example |
|---|---|---|---|
| Constant velocity |  |  |  |
| |  |  |  |

**Important Terms:**

-The independent Variable goes on the horizontal **x- axis** and the dependent variable goes on the vertical **y-axis.**

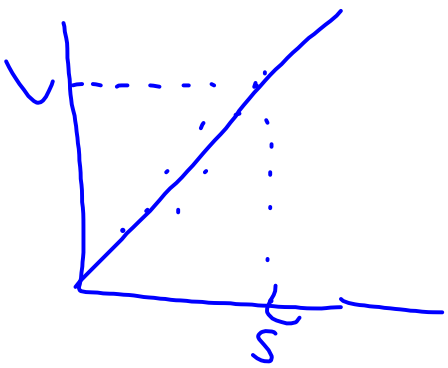
-**Independent Variable:** is the factor that the scientist manipulates or changes in order to determine how other variable(s) respond.

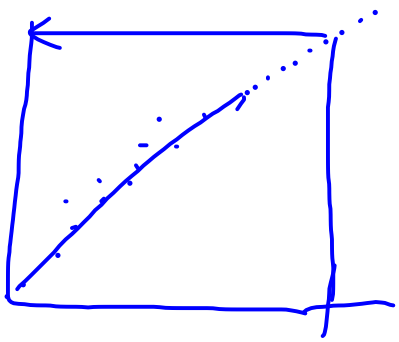
**-Dependent Variable** is the variable(s) that changes in response to changes made to the independent variable.

**Predicting values:**

**Interpolation:** predicting results within the given bounds of a set of data

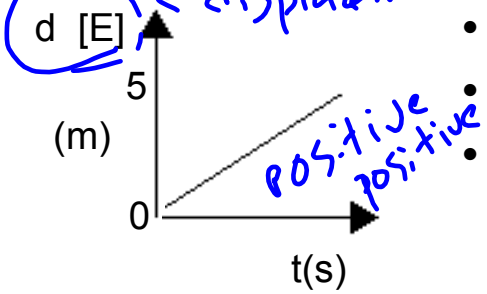
**Extrapolation:** predicting results outside the given bounds of a set of data



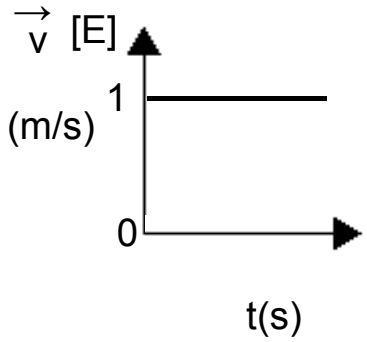
## I. *For a positive velocity:*

A. position vs. time




- These graphs will always have straight lines
- The slope represents the **velocity**
- A horizontal line means the object is **stopped**

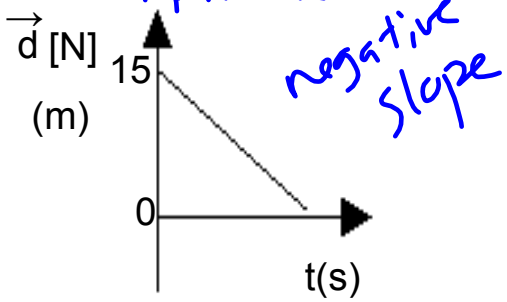
B. velocity vs. time



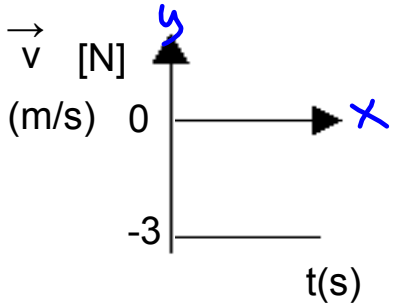

- These graphs will always have a straight horizontal line
- The slope represents the **acceleration**
- The area under the velocity-time graph is the **displacement.**

## II. *For a negative velocity:*

C. position vs. time

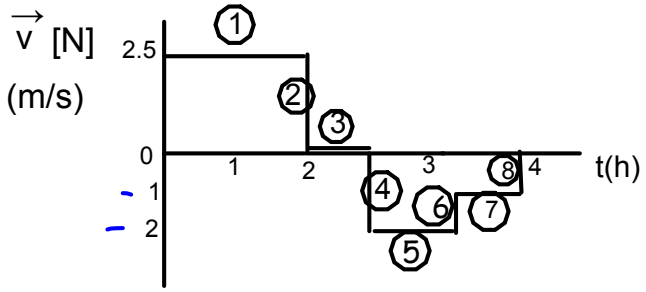



velocity vs. time



**Describe the graph.**

**A jogger is out for a run. The velocity- time graph is shown below. For each letter section of the graph, described the motion of the jogger.**




**1)Jogger runs north at a constant velocity of 2.5 m/s for 2 hours**

**2) slows down and stops at 2 hours.**

**3) stop for 0.5 hour**

**4) speeds up in the south direction**

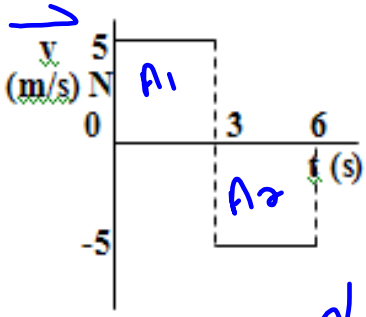
**5) travels at a constant velocity of 2m/s in south direction for 1 hour**

**6) slows down** to 1m/s

**7) travels at a constant velocity of 1m/s in south direction for 0.5 h**

**8) slows down and stops.**

**Ex: a) What distance is represented by the following graph?**
**b) What displacement is represented by the following graph?**




Area = l x w

$A_1$ = 5 x 3 = 15 m

$A_2$ = 3 x 5 = 15m

distance = 15 + 15 = 30m

displacement

$A_1$ = l x w = 5 x 3 = 15M

$A_2$ = 3 x -5 = -15M

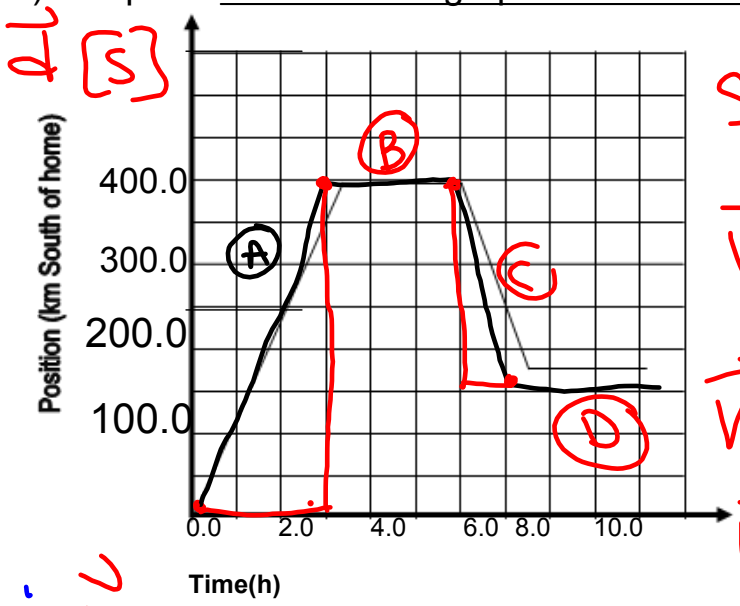
$\vec{d}$ = 15m + -15M

= 0M

**Thus displacement is 0 m, which means the object has returned to its starting position.**

Ex : The position-time graphs below depict 2 car trips. For each graph, calculate the velocity at each interval , draw vt graph and then describe the motion represented by each section

a) Graph 1: Position-time graph for a summer car trip




$\vec{d}$ [S]

$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{400.0}{3}$

$\vec{V}_A = 133.3\ \text{km/h}$ [S]

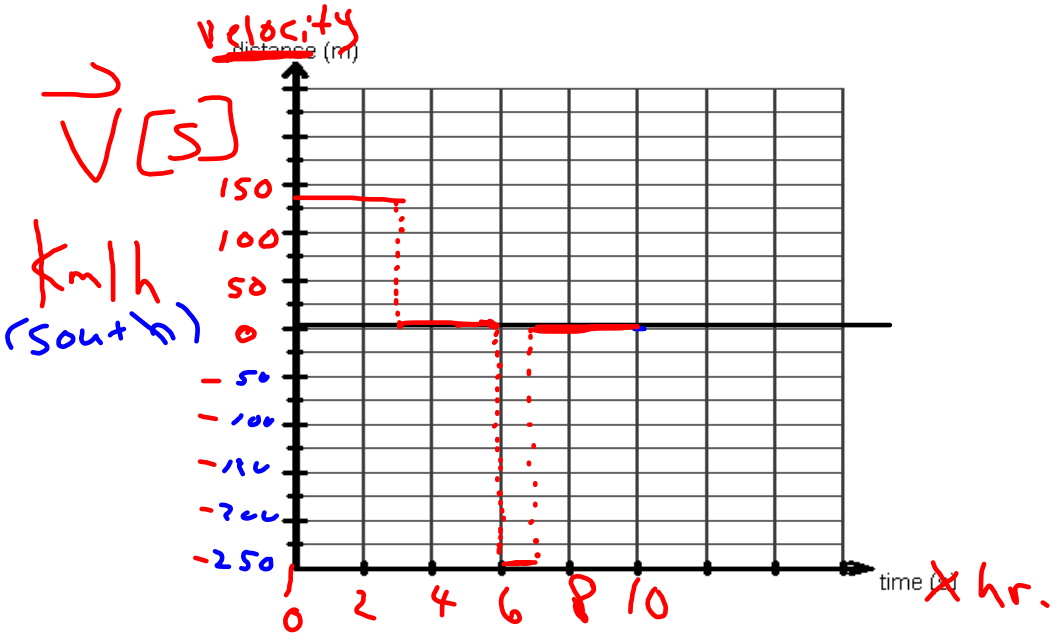
$\vec{V}_B = 0\ \text{km/h}$ [S]

$\vec{V}_C = \frac{\text{rise}}{\text{run}} = \frac{-250\ \text{km/h}}{1\ \text{hr}}$ [S]

$= -250\ \text{km/h}$ [S]

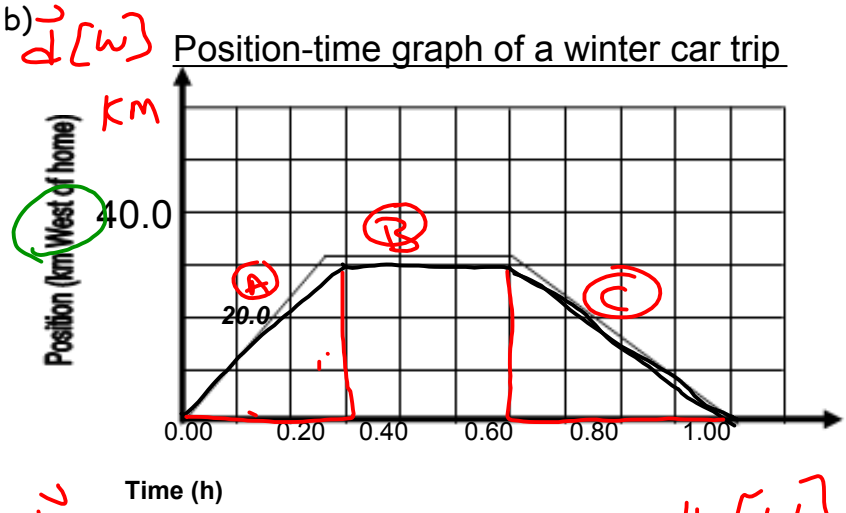
$= 250\ \text{km/h}$ [N]

$\vec{V}_D = 0\ \text{km/h}$ [S]




**answer:** A car travels south at a constant velocity of 133 km/h for 3.0 h, stops for 3.0 h, then travels north at a constant velocity of 250 km/h for 1.0 h, then stops again for 3.0 h.

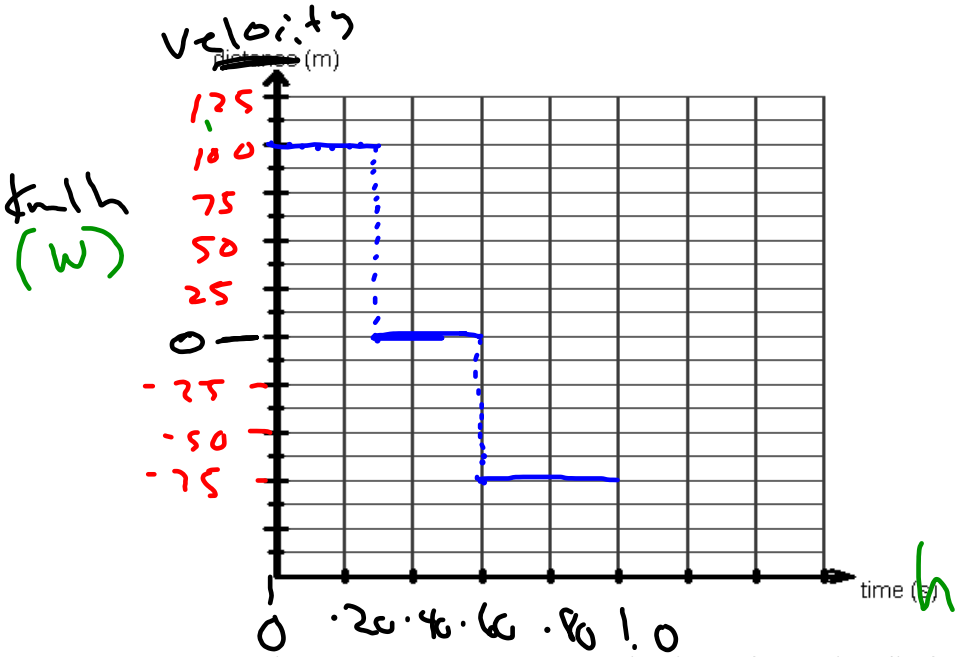
b)




$v_A = \frac{rise}{run} = \frac{30.0\ km}{0.30\ h} = 100\ km/h\ [W]$

$v_B = 0\ km/h\ [W]$

$v_C = \frac{rise}{run} = \frac{-30.0\ km}{0.4\ hr} = -75\ km/h\ [W] = 75\ km/h\ [E]$




**answer:** A car travels west at a constant velocity of 100 km/h for 0.30 h, stops for 0.30 h, then travels east at a constant velocity of 75 km/h for 0.40 h.

Practice questions p. 486 #1,2a,c,d,e,4,9.

486 # 1, 2 (a c d, e)

4, 9

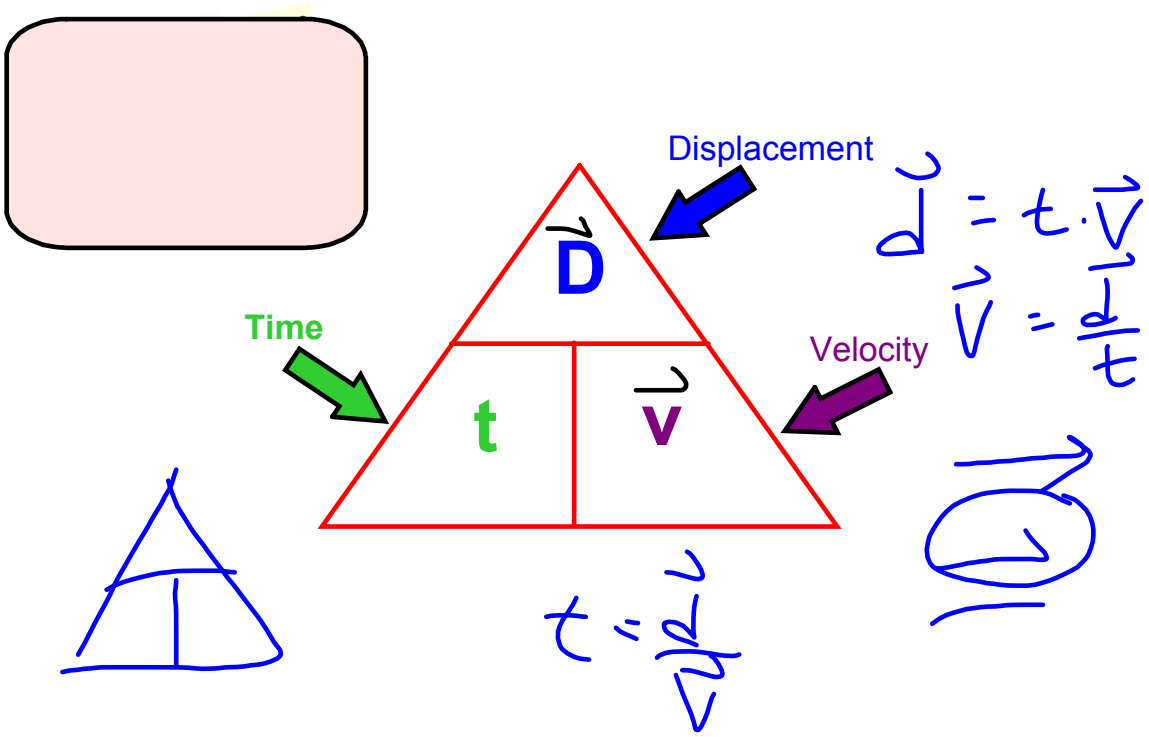
**Velocity**

$\bar{v} = \frac{\bar{d}}{t}$ where $\bar{d}$ is displacement and t is time.

**Velocity (operational definition): A speed along with a direction.**

**Note that the direction of velocity will always be in the same direction** as the displacement.

***Calculations:*** Average Velocity = $\frac{\text{total displacement}}{\text{total time}}$




Ex 1: A car travels 200.0 m [E] and then 100.0 m [W] in 10.0 s. What is its average velocity?

$\vec{d} = 200.\text{m}[E] + 100.0\text{m}[W]$

$\vec{d} = 200.0\text{m}[E] - 100.0\text{m}[E]$

$\vec{d} = 100.0\text{m}[E]$

$\vec{V} = \frac{\vec{d}}{t} = \frac{100.0\text{m}[E]}{10.0\text{s}} = 10.0\text{m/s}\,[E]$

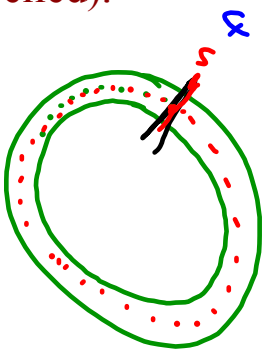
## Sample Problem 2

A person runs 2 laps around a circular track having a radius of 2.0 m in 125 s. What is the person's average velocity?

**Solution:**

$C = 2\pi r$

Since the displacement around a circular track is 0 m, the velocity must also be 0. (The speed however would have a value because it is concerned with the total distance travelled).



$\vec{d} = 0$

$\vec{v} = \frac{\vec{d}}{t} = \frac{0}{125\ sec}$

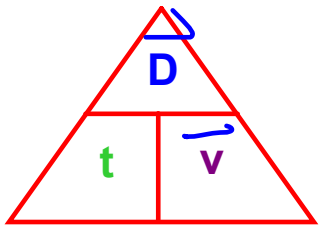
$\vec{v} = 0\ m/s$

## Sample Problem 3

A soccer player warming up for a game jogs along a track. She jogs 50.0 m (N) and then jogs 30.0 m back toward her starting point before stopping to talk to her coach. If she jogged for 20.0 s, determine her average velocity.

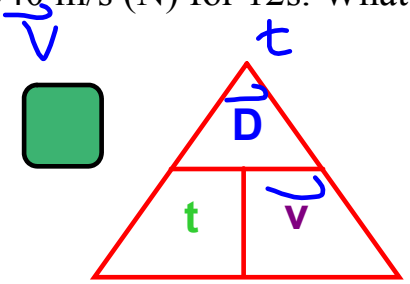
$\vec{d}$ = 50.0m (N) + 30.0 m (S)

$\vec{d}$ = 50.0m (N) - 30.0 m (N) = 20.0 m (N)




$\vec{v} = \frac{\vec{d}}{t} = \frac{20.0\ m\ [N]}{20.0\ s} = 1.00\ m/s\ [N]$

Ex4: A rocket travels at an average velocity of 340 m/s (N) for 12s. What is the rocket's displacement?




$\vec{d} = t \cdot \vec{v}$

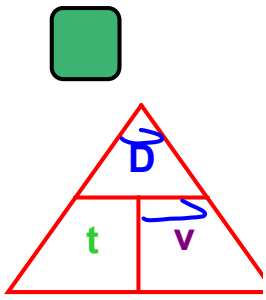
$(12\,sec)(340\,m/s\,[N])$

$= 4080\,m\,[N]$

$= 4100\,m\,[N]$

$or\ 4.1 \times 10^3\,m\,(N)$

**Ex5**: Monarch butterflies migrate from North America to Mexico each year. If during one part of the journey a particular butterfly travels 230.0 km South at an average velocity of 19km/h South, how long does it take for the butterfly to complete this part of the migration?




$t = \frac{\vec{d}}{\vec{v}} = \frac{230.0\,km\,(S)}{19\,km/h\,[S]}$

$t = 12.105\,h$

$t = 12\,h$

**Practice problems p. 436 #1,2 and review questions p. 376 #7-14.**

***Comparing Average Speed and Average Velocity:***

***<u>Ex1:</u> A jogger runs 52 m East in 10.0 s and then 41 m West for 8.0 s. What is the jogger's average speed and average velocity?***

$d = 52 + 41 = 93\ m$

$t = 10.0 + 8.0 = 18.0\ s$

$V = \frac{d}{t} = \frac{93\ m}{18.0\ s}$

$= 5.2\ m/s$

$V_{Avg} = \frac{\text{total distance}}{\text{Total time}}$

$\vec{d} = 52[E] + 41[W]$

$\vec{d} = 52[E] - 41[E]$

$= 11\ m[E]$

$t = 10.0 + 8.0 = 18.0\ s$

$\vec{V} = \frac{\vec{d}}{t} = \frac{11\ m[E]}{18.0\ Sec}$

$= 0.61\ m/s\ [E]$

$\vec{V}_{AVG} = \frac{\text{total } \vec{d}}{\text{Total time}}$

***Ex2:*** A jogger runs at 5.20 m/s North for 125s and then 6.40 m/s South for 90.0s. What is the jogger's average speed and average velocity?

$\vec{d} = t \cdot V$
$= (125\ sec)(5.20\ m/s\ [N])$
$= 650.\ m\ [N]$

$d = 650 + 576\ m$
$= 1226\ m$

$t = 125 + 90.0$
$= 215\ sec$

$V_{Avg} = \frac{d}{t} = \frac{1226\ m}{215\ sec} = 5.70\ m/s$

$\vec{d} = t \cdot V$
$= (90.0\ sec)(6.40\ m/s\ [S])$
$= 576\ m\ [S]$

$\vec{d} = 650.[N] + 576\ [S]$
$= 650.[N] - 576\ [N]$
$= 74\ m\ [N]$

$\vec{V}_{Avg} = \frac{\vec{d}}{t} = \frac{74\ m\ [N]}{215\ sec}$
$= 0.34\ m/s\ [N]$

***Ex3:*** A distance runner runs 26km West for 3.2 hours and then 22 km East for 2.8 hours. What is the runner's average speed and average velocity?

$d = 26 + 22\ km$
$= 48\ km$

$t = 3.2 + 2.8 = 6.0\ h$

$V_{Avg} = \frac{d}{t} = \frac{48\ km}{6.0\ hr}$
$= 8.0\ km/h$

$\vec{d} = 26\ [W] + 22\ [E]$
$\vec{d} = 26\ [W] - 22\ [W]$
$= 4\ m\ [W]$

$\vec{V}_{Avg} = \frac{\vec{d}}{t} = \frac{4\ m\ [W]}{6.0\ hr}$
$= 0.7\ km/h\ [W]$

***Ex4:***A car travels at 120.0 km/h South for 1.50h, turns around and travels 90.0 km/h North for 36 minutes. Find the average speed and average velocity for the trip

$\vec{d} = t \cdot \vec{v}$

$= (1.50\,h)(120.0\,\frac{km}{h}\,[S])$

$= 180.\,km\,[S]$

$36\,min \times \frac{1\,hr}{60\,min} = 0.60\,hr$

$\vec{d} = t \cdot \vec{v}$

$= (0.60\,hr)(90.0\,km/h\,[N])$

$= 54\,km\,[N]$

$\vec{d}_T = 180.[S] + 54\,[N]$

$= 180.[S] - 54[S]$

$= 126\,km\,[S]$

$d_T = 180 + 54 = 234\,km$

$t_T = 1.50h + 0.60h = 2.10h$

$V_{avg} = \frac{d_T}{t_T} = \frac{234\,km}{2.10\,hr} = 111\,km/h$

$\Rightarrow V_{avg} = \frac{\vec{d}_T}{t_T}$

$= \frac{126\,km\,[S]}{2.10\,hr}$

$= 60.0\,km/h\,[S]$