A car travels 150 km at a speed of 80 km/h, then turns around and travels back 150 km at a speed of 60 km/h. What is the car's average speed?

define: average speed = $\frac{\text{distance travelled}}{\text{total time}}$

$|\vec{v}|$ speed

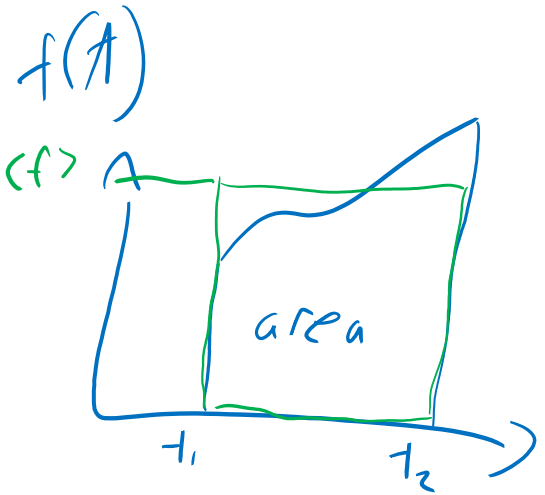
$d = 150$ km

$\langle v \rangle = \bar{v} = v_{avg} = \frac{2d}{t_1 + t_2}$

$t_1 = \frac{d}{v_1}$ $t_2 = \frac{d}{v_2}$

$\langle v \rangle = \frac{2d}{d/v_1 + d/v_2} = \frac{2 v_1 v_2}{v_1 + v_2}$ $\rightarrow 68.6$ km/h

Average Velocity



$$\text{area} = \int_{t_1}^{t_2} f(t)\,dt$$

$$\text{area} = \langle f \rangle (t_2 - t_1)$$

equal

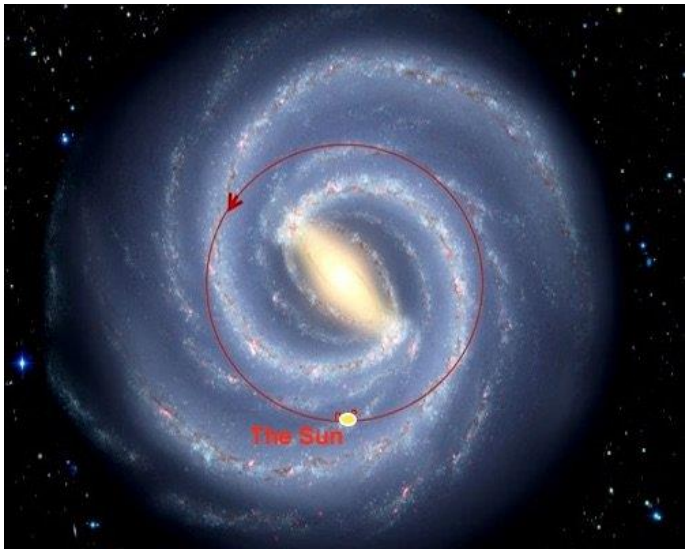
$$\langle f \rangle = \frac{\int_{t_1}^{t_2} f(t)\,dt}{\int_{t_1}^{t_2} dt}$$

$$\langle f \rangle = \frac{\int_{t_1}^{t_2} f(t)\,dt}{t_2 - t_1}$$

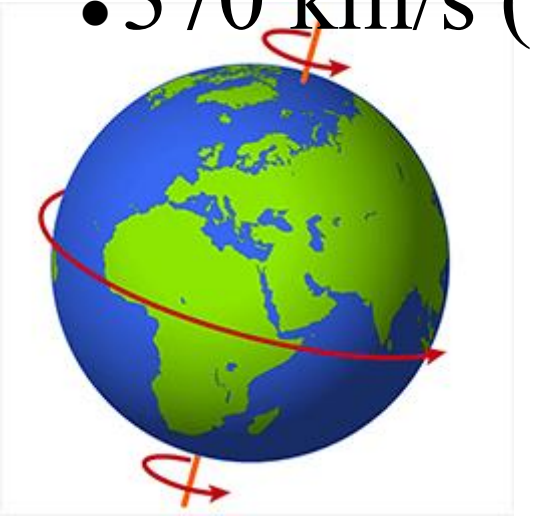
$f \rightarrow v(t)$

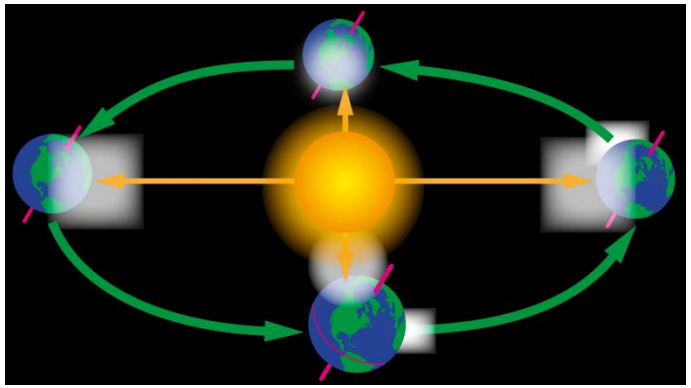
$$\int v\,dt = s_f - s_i$$

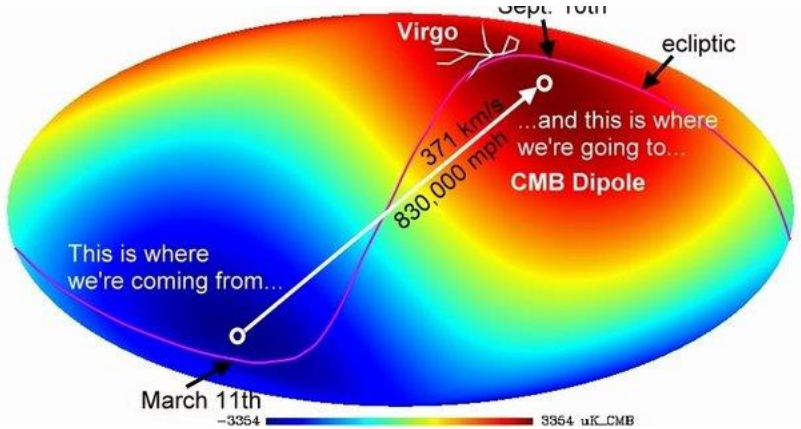
What is my speed right now?



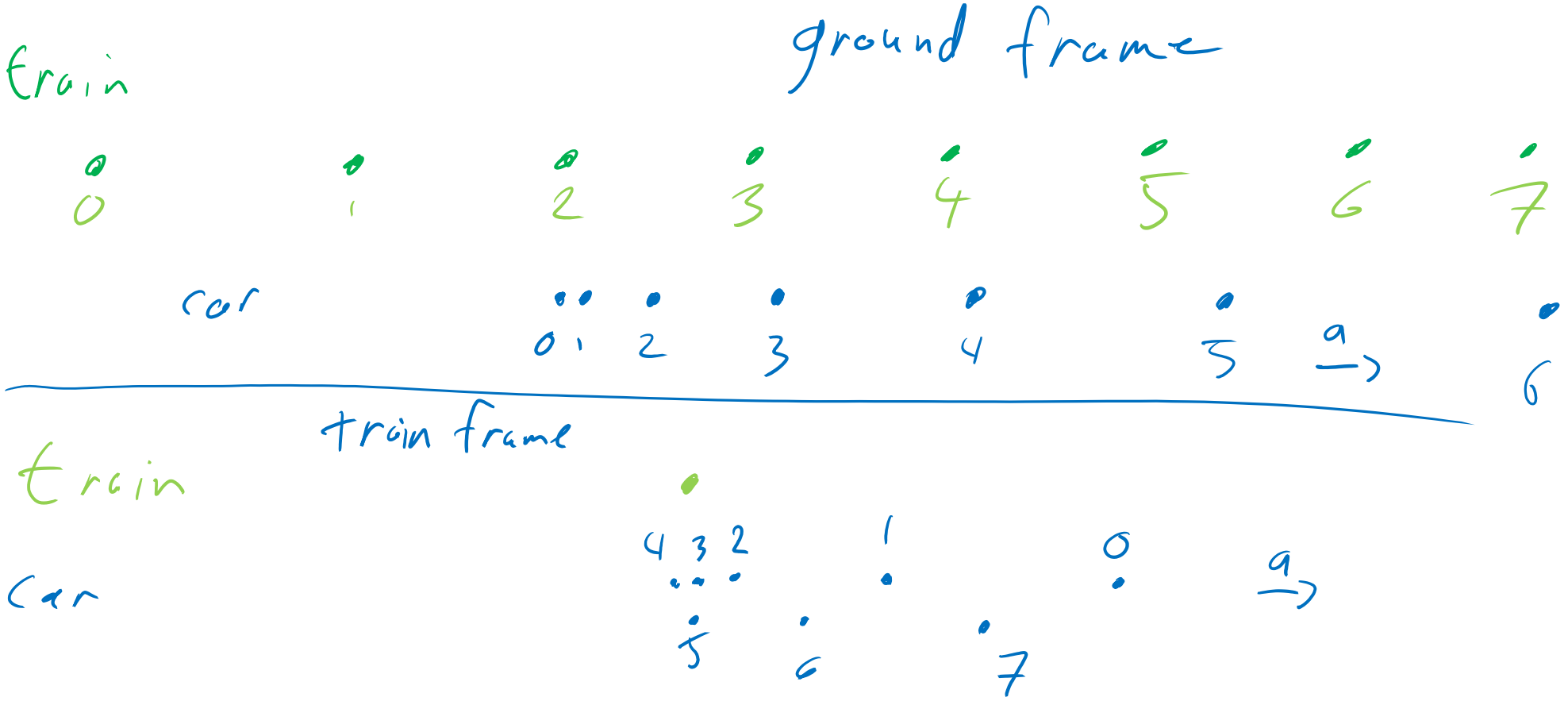
- Zero (relative to the ground)
- 350 m/s (Earth rotates)
- 30 km/s (Earth orbits Sun)
- 230 km/s (Sun orbits Milky Way)
- 580 km/s (Milky way through CMBR)
- 370 km/s (Sun goes “backward” in Milky Way)







A car starts at rest and accelerates north.
A train moves north at constant speed.
Describe the motion of the car relative to the train.



car south, slowing down

then north, speeding up

Team Up Questions

An Olympic sprinter can run 100 m in 10 s, starting from rest. Estimate their top speed assuming exponential decay of acceleration.

assume

$$a(t) = a_0 e^{-t/T}$$

assume $T = 4\,s$

$$v(t) = \int a(t)\,dt + C = a_0 \int e^{-t/T}\,dt + C$$

$$= a_0(-T)e^{-t/T} + C$$

$$t = 0 \rightarrow v = -a_0 T + C = 0 \rightarrow C = a_0 T$$

$$v(t) = a_0 T\left(1 - e^{-t/T}\right) \qquad V_{max} = v(t = 10\,s)$$