GPS: vectors calculated while you move

Many people use GPS (Global Positioning System) navigators, but not everyone knows that these computers constantly calculate vectors for you. Twenty-four GPS satellites orbit Earth at an altitude of 11,000 mi. At most times and places, at least three satellites are visible. Each satellite broadcasts a continual stream that includes its identification, information about its orbit, and a time marker that is precise to one billionth of a second. The satellites' internal clocks and orbits are checked by a ground station that can send correction information.

A GPS receiver listens for the signals from the satellites. When it can get a lock on three or more satellite signals, it calculates how far away each satellite is From the known orbits of each satellite and the distance to each satellite, the receiver can triangulate its position. A calculation from three satellites will give the longitude and latitude of the receiver. A calculation from four satellites will also give altitude.

But where do vectors come in? The receiver does not just triangulate its position once it constantly listens for the satellites and calculates changes in the receiver position from changes in the triangulation results. It calculates any changes in distance and direction from the last known position. Within a very short time it has taken several readings, enough to calculate the velocity of your travel. The result? A speed in a particular direction – a velocity vector – is always part of the receiver's calculations.

There are times when it is not possible to get a good reading on a receiver. Perhaps you have driven under a bridge or through a tunnel. If the GPS receiver is unable to lock onto a meaningful signal, it will start from your last known position. It will then use your last known velocity and direction to calculate a dead reckoning. It will assume that you are continuing in the same direction and at the same speed until it is able to get a reliable signal from enough satellites. Once it is able to receive good signals again, it will make corrections to your position and your course.

(Taken from Paul A. Tipler, Gene Mosca, *Physics for Scientist and Engineers*, p. 82)

EXCERCISES

1 **True or false?**

a. GPS stands for Global Positioning System. T F

b. 34 satellites orbit the Earth. T F

c. When a car goes under a bridge it will probably loose the GPS signal. T F

d. To give altitude the signal from five satellites are needed. T F

2 **Order the sequence.**

..... The GPS makes corrections to your position and your course.

..... The GPS assumes that you are continuing in the same direction and at the same speed.

..... The GPS receiver is unable to lock onto a meaningful signal.

..... You drive through a tunnel.

..... The GPS starts calculating from your last known position.

..... The GPS gets a reliable signal from enough satellites.

..... Then it will use your last known velocity and direction to calculate a *dead reckoning*.

3 **Match questions and answers.**

QUESTIONS		ANSWERS	
A	How many satellites do you need to calculate latitude, longitude and altitude?	1	A velocity vector is always a part of GPS calculation for one's position.
B	What does each satellite broadcast?	2	The GPS needs at least four satellites to calculate the three positions.
C	How does a GPS use vectors?	3	Each satellite broadcasts a continual stream that includes its identification, information about its orbit, and an extremely precise time marker.

A	B	C .....