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Programming Exercise – Wind conversion program

Your task is to create a python script that reads in a time series of wind data expressed as orthogonal vector components u/v (ms^-1) and outputs a time series of wind speed (knots) and meteorological wind direction. (See Appendix A for definitions)

Sample input data will be provided to you the form of a csv file called sample.csv, where the vector components u/v are available every minute. Assume the wind speed is in meters per second.

The program should take an optional argument that specifies whether or not to perform a 10-minute average of the data.
If a 10-minute average is requested the data need only be output every 10 minutes.

Please see Appendix B for requested output format.

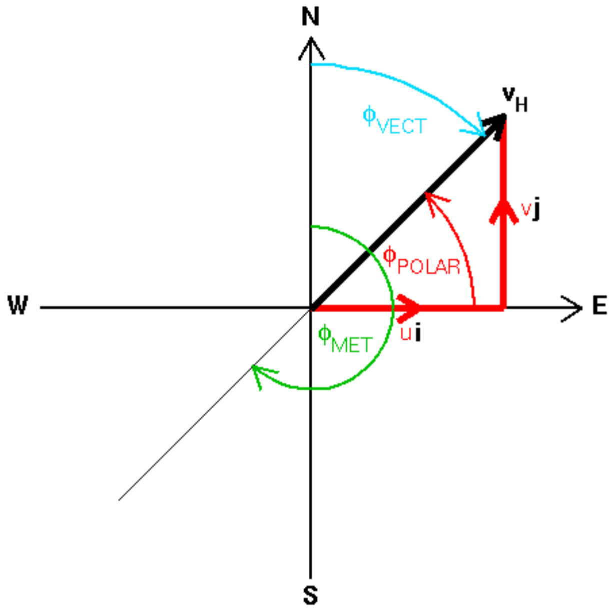
The solution submitted should include source code and any tests or test code you deem necessary. Ideally the project will be made available as a zipped GitHub or bitbucket project.

While this is a toy problem, please solve it as it were intended for production.

Appendix A - Meteorological Wind Direction

The following information is taken from
http://tornado.sfsu.edu/geosciences/classes/m430/Wind/WindDirection.html

The horizontal wind vector, $\mathbf{v_H}$, is represented by the bold black line in the diagram below; **i** and **j** represent unit vectors towards East and North, respectively. Equations for converting horizontal wind vector information between the different notation conventions are given at the bottom of this page.



The wind vector can be expressed either in terms of orthogonal velocity components, where:

> u is the ZONAL VELOCITY, i.e. the component of the horizontal wind TOWARDS EAST.
> v is the MERIDIONAL VELOCITY, i.e. the component of the horizontal wind TOWARDS NORTH.
> (the symbol w is used for the VERTICAL VELOCITY, which is typically +ve for an upward velocity).

or as a wind speed, i.e. | $\mathbf{v_H}$ |, and direction. Particular care should be taken when dealing with the direction since two opposite conventions are commonly used:

> φ_{VECT} is the WIND VECTOR AZIMUTH, i.e. the direction TOWARDS which the wind is blowing. It increases clockwise from North when viewed from above. Terms such as northward, eastward etc. imply wind vector azimuths.
>
> φ_{MET} is the METEOROLOGICAL WIND DIRECTION, i.e. the direction FROM which the wind is blowing. It also increases clockwise from North when viewed from above. Terms such as northerly, easterly etc. imply meteorological wind directions.

These directions are typically expressed in units of degrees, φ(deg), but can either be in the interval -180° to +180° or 0° to 360°. The wind vector azimuth and meteorological convention direction are related by:

$$\phi_{MET}(deg) = \phi_{VECT}(deg) + 180$$

subtracting 360° where appropriate in order to keep the values within the desired range. Note that when writing a computer program to convert between speed/direction and orthogonal component conventions, the use

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of trigonometric functions assumes that angles are expressed in units of radians, φ(rad), rather than degrees (pocket calculators can typically perform trigonometric functions on angles expressed in either units). Directions are converted from units of degrees to radians through the relationship:

$$\phi(rad) = \frac{\pi}{180} \times \phi(deg)$$

Moreover, the familiar expressions relating the x component of a vector to the cosine of its angle and the y component to its sine imply use of:

> φ_{POLAR} which is the WIND VECTOR POLAR ANGLE in two-dimensions. It increases ANTICLOCKWISE FROM the +ve x-axis, i.e. from EAST; this in the opposite sense to the wind vector azimuth and the meteorological wind direction, and from a different origin.

When converting back from orthogonal components to speed and direction, the **atan2(y,x)** function should be used in order to avoid ambiguity in the returned value of the wind vector polar angle. The expressions below can be used to convert horizontal wind vector information directly between the orthogonal component and speed/direction conventions without the need for first converting directions between wind the vector polar angle and the wind vector azimuth or meteorological wind direction.

Wind Vector Azimuth	**Meteorological Wind Direction**
$u = \lvert \boldsymbol{v_H} \rvert \times \sin\left[\frac{\pi}{180} \times \phi_{VECT}(deg)\right]$	$u = -\lvert \boldsymbol{v_H} \rvert \times \sin\left[\frac{\pi}{180} \times \phi_{MET}(deg)\right]$
$v = \lvert \boldsymbol{v_H} \rvert \times \cos\left[\frac{\pi}{180} \times \phi_{VECT}(deg)\right]$	$v = -\lvert \boldsymbol{v_H} \rvert \times \cos\left[\frac{\pi}{180} \times \phi_{MET}(deg)\right]$
$\phi_{VECT}(deg) = \frac{180}{\pi} \times \mathrm{atan2}(u, v)$	$\phi_{MET}(deg) = \frac{180}{\pi} \times \mathrm{atan2}(-u, -v)$

$$|\boldsymbol{v_H}| = \sqrt{u^2 + v^2}$$

Appendix B: output format

Output of the program should be in csv format. Please use the following format for the header and data

datetime,WindSpeed,WindDir
YYYY-MM-DD HH:MM:SS,VALUE,VALUE

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Float VALUES need only be to 6 decimal places.