24-780 Engineering Computation Problem Set 03

You need to create a ZIP file (It may appear as a compressed folder in Windows) and submit the ZIP file via the 24-780 Canvas. The file name of the ZIP file must be:

PS03-YourAndrewID.zip

For example, if your Andrew account is *hummingbird@andrew.cmu.edu*, the file name must be:

PS03-hummingbird.zip

If your ZIP file does not comply with this naming rule, you will automatically lose 5% credit from this assignment. If we are not able to identify who submitted the file, you will lose another 5% credit. If we finally are not able to connect you and the submitted ZIP file, you will receive 0 point for this assignment. Therefore, please make sure you strictly adhere to this naming rule before submitting a file.

The ZIP file needs to be submitted to the 24-780 Canvas. If you find a mistake in the previous submission, you can re-submit the ZIP file with no penalty as long as it is before the submission deadline.

Notice that the grade will be given to the final submission only. If you submit multiple files, the earlier version will be discarded. Therefore, if you re-submit a ZIP file, the ZIP file MUST include all the required files. Also, if your final version is submitted after the submission deadline, late-submission policy will be applied no matter how early your earlier version was submitted.

Make sure your program can be compiled with no error in one of the compiler servers. Don't wait until the last minute. Compiler servers may get very busy minutes before the submission deadline!

The ZIP file needs to include:

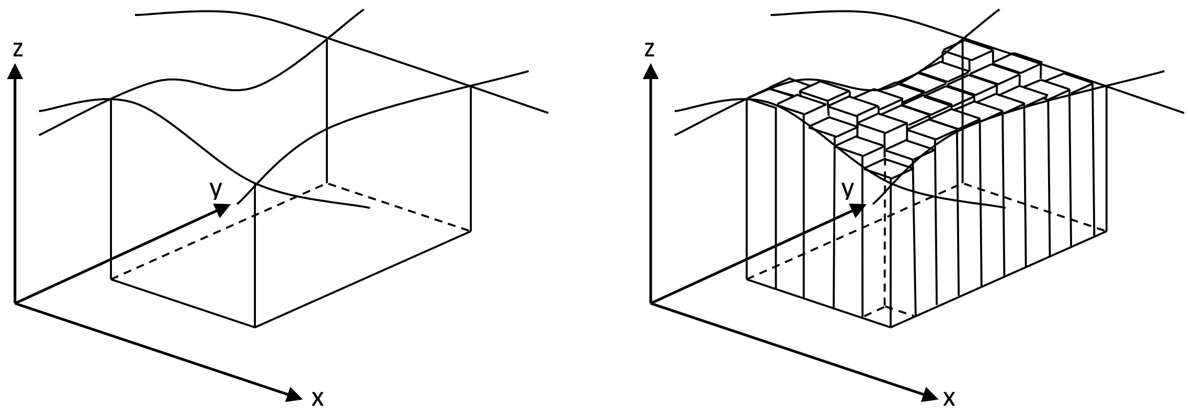
Two CPP files from PS3-1 (ps3-1.cpp) and PS3-2 (ps3-2.cpp)

Submission Due: Please see Canvas

START EARLY!

Unless you are a good programmer, there is no way to finish the assignment overnight.

PS3-1 Numerical Double Integration



For a function $z = f(x,y)$, double integration:

$$\int_{x_0}^{x_1}\int_{y_0}^{y_1} z dx dy$$

gives a volume above the rectangle defined by $x_0 \le x \le x_1,\ y_0 \le y \le y_1, z = 0$ and below the surface defined by the function $z = f(x,y)$. It can be numerically calculated by dividing the scope into small rectangular sub-regions and summing up the volume of the rectangular solid above each sub-region. The height of a rectangular solid can be measured by sampling the function $z = f(x,y)$ for x and y within the sub-region. Easiest choice is taking minimum x and y within the sub-region.

In PS3-1, you write a program called ps3-1.cpp that numerically calculates the following double integration:

$$\iint_0^1 g(x,y) dx dy$$

where

$$g(x,y) = \begin{cases} \sqrt{1 - x^2 - y^2} & \text{for } x^2 + y^2 \le 1, \\ 0 & \text{otherwise.} \end{cases}$$

The program must prompt the user as:

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Enter Integration Step>
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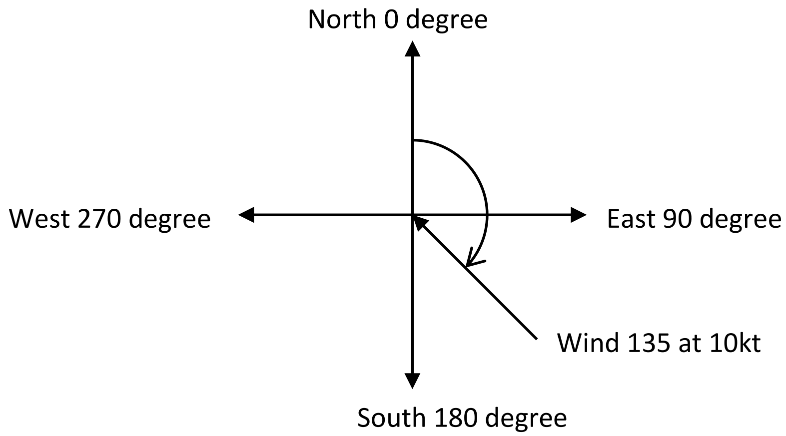
and take the integration step h from the console window, and print the result on the console window.

The C++ source file must be included in the Zip file that you submit to the digital drop box. Your code should yield no more than 0.2% error from the analytical solution for h=0.001.

PS3-2 Digital flight computer for calculating the heading.

A flight computer is used for flight planning. One of its functionality is to find the heading angle of an airplane that makes the airplane fly along the planned straight course based on the forecasted wind.

The heading angle is defined as: 0 degree is north, 90 degree is east, 180 degree is south, and 270 degree is west. Wind 135 at 10kt means that the wind is blowing FROM the south east at 10kt.



When the following parameters are given:

θ_w	Wind direction	v_w	Wind velocity
θ_c	Desired course	v	Airspeed,

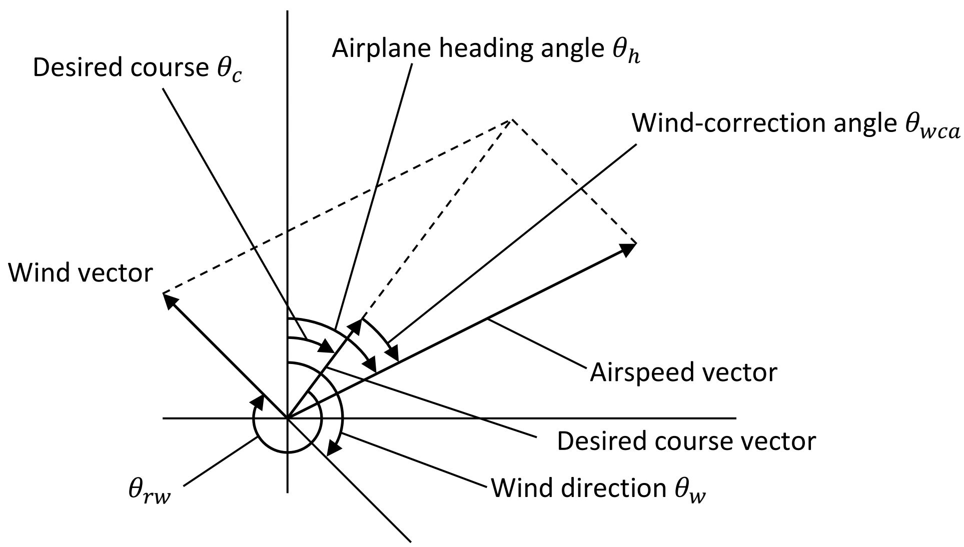
the heading that the airplane should take θ_h and the ground speed v_g can be written as:

$$\theta_h = \theta_c + \theta_{wca},$$
$$v_g = v\cos\theta_{wca} + v_w\cos\theta_{rw},$$

where

$$\theta_{rw} = \theta_w + 180° - \theta_c,$$
$$\theta_{wca} = \operatorname{asin}\left(\frac{-v_w \sin\theta_{rw}}{v}\right) \quad (\theta_{wca} \text{ is known as wind-correction angle.})$$

If the pilot maintains the heading θ_h and airspeed v, ground velocity vector aligns with the desired course, and the ground speed will be v_g.



In PS3-2, you write a program that takes (1) wind direction, (2) wind velocity, (3) desired course, and (4) air speed, and shows (a) the heading angle that the airplane should take and (b) expected ground speed. In addition to print (a) and (b), your program shows a visual aid that makes a pilot to visually see the relation of the wind, airplane heading, and ground speed. After calculating (a) and (b), your program needs to open 800x600 window, and draw an empty black circle centered at (400,300). The radius of the circle should be 100 pixels.

Then, draw blue, red, and green lines that indicate the desired course, wind, and the airplane heading, respectively. The length of the blue line should be ground speed times 3 pixels, red line wind speed times 3 pixels, and green line airspeed times 3 pixels. Airspeed and wind speed are described in kt (knots). <u>(* The formulation is given, and all you need to draw on the graphics window is a circle and three lines!)</u>

After drawing the visual aid, your program needs to wait for the key stroke on the graphic window before terminating.

Write the C++ program (ps3-2.cpp). Then run the program and save a screenshot of the graphic window in PNG format as ps3-2.png for the following input.

Wind direction 220 Wind speed 15kt Course 235 Airspeed 125kt

Include ps3-2.cpp in the Zip file that you submit to the canvas.

Sample Running Image