1. (20 points) Explain the Kutta-Joukowski Law (you don't need to derive all the equations but would be good to use some). In relation to the Kelvin's theorem, explain how one can use this law.

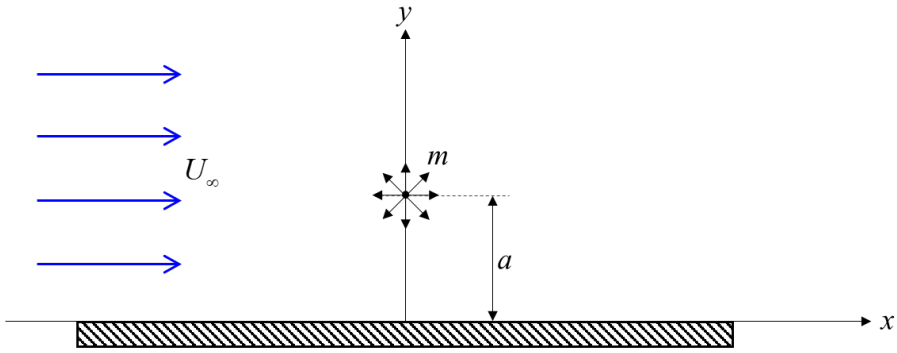
2. (20 points) A two-dimensional ellipsoidal cylinder (ratio of major axis to minor axis is α:1, major axis is along the vertical direction) is moving in vertical direction with a constant velocity U. Using the modified Joukowski Transformation (i.e., Joukowski constant $c = ib$), calculate the pressure coefficient defined as $c_p = (p - p_\infty)/(0.5\rho U^2)$, in terms of α, at the end positions of short axis. (p_∞: pressure at free-stream condition)

3. (20 points) A long circular cylinder of diameter D [m] is set horizontally in a free stream of velocity U [m/s] and caused to rotate clockwise at ω [rad/s].

   (a) (10 points) Obtain an expression in terms of ω and U for the ratio of the pressure difference between the top and bottom of the cylinder to the dynamic pressure of the free stream.
   (b) (10 points) Explain the behavior of the stagnation lines of such a system as ω increases from zero while keeping U constant.

4. (15 points) Prove that the chord length of a Joukowski airfoil is constant as $4c$ (c: Joukowski constant).

5. (25 points) In a 2D potential flow, consider the flow induced by a source located at a distance (a) from a plane wall in the horizontal uniform flow (speed U). The source strength (m) equals to Ua.



   (a) (5 points) Find the complex potential.
   (b) (5 points) Find the location of the stagnation points on the wall.
   (c) (15 points) Calculate pressure coefficient (c_p) along the wall. Definition of c_p is same as problem 2. Is there any separation point on the wall at leeside of the source ($x > 0$)? If the separation point exists, indicate where flow separation might occur.