※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. (20%) Consider a steady 2D flow field with velocity $u = -5y$ and $v = 5x$ where u and v are the Cartesian velocity components, and x and y are the Cartesian coordinates.

(a) Derive the stream function $\psi(x, y)$ for the flow field. To determine the integration constant, assume that the streamline passing through (1, 1) has $\psi = 0$.

(b) Verify whether this flow is compressible or incompressible.

(c) What is the angular velocity of this flow? Verify whether this flow is rotational or irrotational.

(d) Suppose you are standing fixed at the origin and you are measuring the acceleration vector of the flow at point (2, 2). What is the acceleration vector you will obtain?

(e) Suppose now you are flowing with a fluid element that passes through the point (2, 2). What is the acceleration vector you will be experiencing when you pass through (2, 2)?

2. (20%) The Taiwan high speed train is moving at 180miles/hour. 90% of its power consumption is basically to overcome the fluid drag in motion. If the front view cross sectional area is 120 square ft, and the drag coefficient is 0.3, what is the horse power required to move the train at the above speed? (air density is 0.00238 slug/cubic ft).

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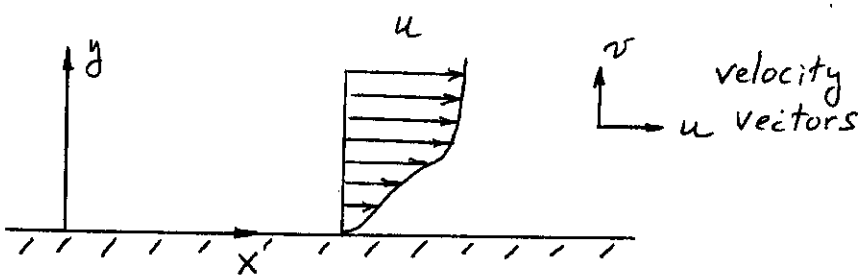
3. (20%) If the velocity of an incompressible viscous flow near the wall can be described as

$$u = ay + by^2 + cy^3 + \cdots$$

1) Determine the vertical velocity distribution v;
2) Determine the wall shear stress;
3) Find the pressure gradient for this flow.



4. (20%) In two-dimensional incompressible, let (u,v) be velocity.
a) Give the definitions of vorticity and stream function.
b) Give the definitions of streamline, pathline, and streakline.
c) Give the definition of circulation within a closed curve.
d) Give the definition of Reynolds number.

5. (20%) 假若有一個低速風洞(low speed wind tunnel)的進口截面積為 A_1、空氣的壓力為 P_1、密度為 ρ_1。而風洞測試段內的截面積為 A_2、空氣壓力為 P_2，然而空氣密度保持不變，且摩擦損失亦不計。假設此風洞的進口空氣速度為 V_1，則測試段內的風速 V_2 應為多少？(10%) 當有一架飛機模型置於此風洞的測試段內進行性能測試，若此模型的截面積(cross section area)約佔測試段截面積的8%，則此時測試段的風速 V_2 變為多少？(10%)