# Aerodynamics-II
# VTU CBCS Question Paper Set
# 2018

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10AE63

# Sixth Semester B.E. Degree Examination, Dec.2014/Jan.2015

## Aerodynamics – II

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***



## PART – A

1 a. Derive the velocity potential at a point P at a distance r from a source sheet of strength λ per unit length. **(10 Marks)**

b. Consider lifting flow over an arbitrary body and derive an expression for total surface velocity induced at the $i^{th}$ control point employing vortex panel method. **(10 Marks)**

2 a. Explain the following:
i) Downwash and induced drag
ii) Biot-Savarth law
iii) Helmholtz's vortex theorem **(06 Marks)**

b. Explain and derive Prandtl's lifting line theory and its limitations. **(06 Marks)**

c. Derive expressions for lift, induced drag and downwash for elliptic lift distribution. **(08 Marks)**

3 a. Derive the governing velocity potential equation for an inviscid, compressible, irrotational subsonic flow over a body immersed in a uniform stream. **(10 Marks)**

b. Derive and explain the Prandtl Glauset compressibility correction formula. **(06 Marks)**

c. At a given point on the surface of an airfoil, the $C_p$ is -0.3 at very low speeds. If the free stream mach no. is 0.6, calculate $C_p$ at this point? **(04 Marks)**

4 a. Define: i) Mach waves and expansion waves, ii) Normal and oblique shocks. **(04 Marks)**

b. What is critical mach no.? Derive an expression for critical pressure coefficient in terms of critical mach no.? **(10 Marks)**

c. Explain: i) Drag-Divergence Mach number, ii) Sound barrier and iii) Transonic area rule. **(06 Marks)**

## PART – B

5 a. Explain in detail the influence of downwash on tail plane. **(08 Marks)**

b. Explain with figure the formation flying effect and ground effect. **(06 Marks)**

c. Prove that for a monoplane a rotational formula for the downwash, in degrees at the tail plane is $\varepsilon = \text{constant} \times \dfrac{CL}{AR}$. Determine the numerical value of the constant for a point on the center line of the machine 2s/3 behind the centre of pressure, s being the semi-span. **(06 Marks)**

6 a. What are cylindrical coordinates used for bodies of revolution and velocity potential in cylindrical coordinates? **(06 Marks)**

b. Derive linearised supersonic pressure coefficient formula. **(14 Marks)**

7 a. What are swept back wings? How the performance of an airplane is improved by the application of swept back wing's concept? **(10 Marks)**

b. What are high lift devices? Explain. Describe the functions of different types of flaps with figures. **(10 Marks)**

8 With neat sketch, describe the process of flow over a flat plate, also stating the assumptions explain the phenomenon of turbulent boundary layer properties over the same flat plate at low speeds. **(20 Marks)**

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**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***

## PART – A

1 a. What is a source sheet? Explain. Derive the velocity potential at a point P at a distance r from a source sheet of strength λ per unit length. **(10 Marks)**

b. Consider lifting flow over an arbitrary body and derive an expressions for total surface velocity induced at the '$i$'$^{th}$ control point employing vertex panel method and application of Kutta condition. **(10 Marks)**

2 a. Derive fundamental equation of Prandtl's Lifting line theory. **(10 Marks)**

b. State Biot-Savart law and derive velocity induced at a particular point due to semi-infinite vertex. **(10 Marks)**

3 a. Obtain linearized potential flow equation for flow over airfoil using small perturbation theory. **(12 Marks)**

b. Briefly explain Boundary condition in consistent with linearized velocity potential equation. **(04 Marks)**

c. For a thin symmetric airfoil in an incompressible flow, the coefficient of lift is $C_l = 2\pi\alpha$, where $\alpha$ is angle of attack. Find the increase in co-efficient of lift curve slope when Mach number is increased to 0.7. **(04 Marks)**

4 a. What is critical Mach number? Derive an expression for critical pressure coefficient in terms of critical Mach number. **(10 Marks)**

b. Derive an expression for speed of sound for isentropic condition. **(10 Marks)**

## PART – B

5 a. Briefly explain: (i) Formation flight. (ii) Ground effects. **(10 Marks)**

b. An aeroplane of weight 'W' and span '2s' is flying horizontally near the ground at altitude 'h' and speed 'V'. Estimate the reduction in drag due to ground effect. If $W = 22\times10^4$ N, h = 15.2 m, s = 13.7 m, V = 45 m/s. Calculate the reduction in Newtons. **(10 Marks)**

6 a. Derive pressure coefficient using small perturbation values. **(10 Marks)**

b. Describe the subsonic flow past an axially symmetric body of revolution at zero-incidence. **(10 Marks)**

7 a. What is a swept wing? Bring out the aerodynamic characteristics of swept wing, with relevant graphs and sketches. **(10 Marks)**

b. What are High Lift devices? List them and explain their effects an aerodynamic characteristics with suitable graphs. **(10 Marks)**

8 a. Derive the Navier-stokes equation for two-dimensional flow. **(10 Marks)**

b. Briefly explain about Boundary-layer properties. **(10 Marks)**

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Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. 2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

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# Sixth Semester B.E. Degree Examination, June / July 2014
# Aerodynamics – II

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***



## PART – A

1 a. Explain vertex panel and derive an expression for total surface velocity induced at its control point, deduce an expression for total circulation and lift per unit for lifting flow over an arbitrary body. **(10 Marks)**

b. Derive an expression for normal velocity, tangential induced velocity and pressure co-efficient at its control point, using source panel distribution method over the surface of a body of arbitrary shape. **(10 Marks)**

2 a. Derive an expression for lift circulation and induced drag co-efficient of circulation strength $\Gamma(y)$ for a finite wing, through Prandtl's classical lifting line theory. **(10 Marks)**

b. Consider a rectangular wing with an aspect ratio of b, an induced drag factor is 0.055 and a zero lift angle of attack -2°. At an angle of attack 3.4°, the induced drag co-efficient for this wing is 0.01. Calculate the induced drag co-efficient for a similar wing (a rectangular wing with same airfoil section) at the same angle of attack, but with an aspect ratio of 10. Assume that the induced factors of drag and the lift slope δ, and τ respectively, are equal to each other. (Consider δ = 0.0105 for AR = 10) **(10 Marks)**

3 a. Derive Prandtl-Glauret compressibility correction for compressible and incompressible flow relation for expressions $C_P$, $C_m$ and $C_L$. **(10 Marks)**

b. Explain the characteristics of transonic airfoils. **(06 Marks)**

c. The critical Mach number of an airfoil is 0.62. Find the critical pressure co-efficient. (Assume γ = 1.4) **(04 Marks)**

4 a. Explain the characteristics of super critical airfoil. **(06 Marks)**

b. The critical Mach number of an airfoil is 0.6 and at a given point on the airfoil, the pressure co-efficient is -0.3 at very low speed. Calculate $C_p$ at that point. **(04 Marks)**

c. Explain the following with a neat sketches:
i) Drag-divergence mach number and sound barrier. **(10 Marks)**
ii) Area rule.

## PART – B

5 a. Write short notes on any two of the following:
i) Formation of flight.
ii) Influence of downwash on tail plane.
iii) Ground effects on aircraft during take-off and landing. **(10 Marks)**

b. Calculate the induced co-efficient of drag for a wing 40 $m^2$ and span of 8 m while for wing of area 60 $m^2$ and span is 10 m, the induced drag co-efficient is 0.015. (Other conditions remain same). **(04 Marks)**

c. Consider a finite wing with an aspect ratio 8 and taper ratio of 0.8. The airfoil section is thin and symmetric. Calculate the lift and induced drag co-efficient for the wing, when angle of attack is at 5°. (Assume δ = 0.055 and δ = τ) **(06 Marks)**

6 a. What are the different types of small perturbation flows? Briefly explain with relevant sketches. **(08 Marks)**

b. Describe the subsonic flows past an axially symmetric body of revolution with relevant sketches. **(12 Marks)**

7 a. List advantages of flaps and slots with neat sketch and briefly explain their advantages for an aircraft at flight. **(10 Marks)**

b. Describe the aerodynamic characteristics of swipt wings at supersonic speeds with relevant graphs and sketches. **(10 Marks)**

8 a. What is the boundary layer theory? Explain laminar, turbulent boundary layer and transition over a flat plate at low speeds. **(10 Marks)**

b. Find the displacement, momentum and energy thickness for the velocity distribution in the boundary layer given by, $\frac{u}{U} = \frac{y}{\delta}$ where u is the flow velocity at a distance (y) from the solid boundary, $u = U$ at $y = \delta$, where $\delta$ is the boundary layer thickness. Also calculate the ratio of momentum thickness to displacement thickness. **(10 Marks)**

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# Sixth Semester B.E. Degree Examination, June/July 2015

## Aerodynamics - II

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

## PART – A

1 a. Explain with neat sketch, Kulta – Joukourshi theorem for the surface of a body of arbitrary shape. **(08 Marks)**

b. Consider non lifting flow over arbitrary body and describe the procedure to calculate the pressure co-efficient at $i^{th}$ control point through source panel method. **(12 Marks)**

2 a. Discuss briefly the following:
i) Vortex filament ii) Induced drag
iii) Biot-Savarh law iv) Helmholtz's vortex theorem **(16 Marks)**

b. Explain the importance of aspect ratio of finite wing. **(04 Marks)**

3 a. Derive the governing velocity potential equation for an inviscid compressible, irrotational subsonic flow over a body immersed in an uniform stream. **(12 Marks)**

b. Explain in brief the Prandtl Glauset compressibility correction. **(08 Marks)**

4 a. Derive the relation for critical pressure coefficient in terms of free stream mach number. **(10 Marks)**

b. Explain how to find the critical mach number for an air foil. **(06 Marks)**

c. The critical mach number for an airfoil is 0.62. Find the critical pressure co-efficient ($\gamma = 1.4$). **(04 Marks)**

## PART – B

5 a. Derive an expression for lift co-efficient and induced drag co-efficient is term of circulation strength $\Gamma(y)$ for a finite wing, through Prandtl's classical lifting line theory. **(14 Marks)**

b. Explain down wash and induced drag. **(06 Marks)**

6 a. Explain with neat sketch, the boundary condition for a 2D (or) axially symmetric body. **(12 Marks)**

b. What are the different types of small perturbation flows? Briefly explain with relevant sketches. **(08 Marks)**

7 a. Discuss the advantages of swept wings modern airplanes. **(08 Marks)**

b. What are high lift devices? List them. Explain their effects on aerodynamics characteristic. **(12 Marks)**

8 a. Derive the Blasuis equation for a incompressible flow over a flat plate. **(12 Marks)**

b. What is the boundary layer theory? Explain laminar, turbulent boundary layer and transition over a flat plate at low speed. **(08 Marks)**

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# Sixth Semester B.E. Degree Examination, June/July 2016

## Aerodynamics – II

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

### PART – A

1 a. Explain source panel methods for non-lifting flows over a arbitrary bodies to find the pressure coefficient at $i^{th}$ control point. Also find normal and tangential velocity. **(10 Marks)**

b. Explain vortex panel method for lifting flow over arbitrary bodies to find lift per unit span at $j^{th}$ control point. **(10 Marks)**

2 a. The circulation distribution over a finite wing is of elliptic form $\Gamma_0 = \Gamma_0\sqrt{1-\left(\frac{2y}{b}\right)^2}$, where $\frac{b}{2}$ is the semi span of wing. Obtain from the closed form of expression, the induced angle of attack and induced drag coefficient. **(10 Marks)**

b. Discuss the effects of induced drag on downwash using finite wing theory horse shoe vortex system. **(10 Marks)**

3 a. Explain the assumption of linearized velocity potential equation and derive an expression for pressure coefficient using linearized velocity potential equation for an invisid, compressible, irrotational flow. **(10 Marks)**

b. Explain the characteristics of transonic airfoils. **(05 Marks)**

c. If critical Mach number of an airfoil is 0.8. Calculate the value of $\frac{p}{p_\infty}$ at the minimum pressure point when $M_\infty = 0.8$. **(05 Marks)**

4 a. Explain a NACA0012 airfoil at zero angle of attack $C_{po} = -0.43$. Estimate the critical mach number by graphical method. **(10 Marks)**

b. Explain the following with neat sketches:
   i) Drag-divergence Mach number and sound barrier.
   ii) Area rule. **(10 Marks)**

### PART – B

5 a. Briefly explain the effects of downwash on:
   i) Formation of flying
   ii) Ground effects on aircraft **(10 Marks)**

b. A twin jet execution transport aircraft with zero angle of attack $\alpha_{L=0} = -2°$, lift slope of airfoil section is 0.1/deg. The lift efficiency factor is 0.004 and wing AR = 7.96. At cruising condition, calculate the angle of attack of the airplane. (At cruise $C_L = 0.21$). **(10 Marks)**

6 a. Enlist the different types of small perturbation flows and briefly explain each with a neat sketch. **(10 Marks)**

b. Describe the subsonic flows past an axially symmetric body of revolution with relevant sketches. **(10 Marks)**

7 a. Explain the advantages of swept sock wings in military airplanes with neat sketches. **(10 Marks)**

b. Explain with a neat sketch 4 flaps and slots, also discuss about their performance characteristics with relevant graphs. **(10 Marks)**

8 a. Define total drag and discuss the boundary layer flow transition over a flat plate and an airfoil. **(10 Marks)**

b. For velocity profile for laminar boundary layer,

$$\frac{U}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2 .$$

Determine:

i) Displacement thickness
ii) Energy thickness
iii) Momentum thickness **(10 Marks)**

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# Sixth Semester B.E. Degree Examination, June/July 2017
## Aerodynamics – II

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***



## PART – A

1 a. Calculate the pressure coefficient distribution around a circular cylinder using the source Panel technique. **(16 Marks)**

b. Explain the difference between source panel and vortex panel methods. **(04 Marks)**

2 a. Derive the expression for the induced AOA and induced drag coefficient using elliptical lift distribution. **(10 Marks)**

b. Derive an expression for lift coefficient and induced drag coefficient in terms of circulation strength $\Gamma(y)$ for a finite wing using through general lift distribution. **(10 Marks)**

3 a. Derive the velocity potential equation for an inviscid, compressible, irrotational, subsonic flow over a body immersed in a uniform flow. **(12 Marks)**

b. At a given point on the surface of an airfoil, the pressure coefficient is 0.3 at very low speeds. If the free stream is 300 m/s at standard sea level conditions, calculate the pressure coefficient at the same point at this speed. **(04 Marks)**

c. The lift coefficient for a thin, symmetric airfoil in an incompressible flow is $C_L = 2\pi\alpha$. Calculate the compressible lift coefficient at a flight velocity at sea level condition is $V_\infty = 248$ m/sec. **(04 Marks)**

4 a. Define and derive continuity, momentum and energy equation for normal shock waves. **(10 Marks)**

b. Consider an airplane flying at a velocity of 250 m/s. Calculate it's Mach number if it is flying at a standard altitude of (i) sea level (ii) 5 km (iii) 10 km. Assume $T_\infty$ at sea level = 288 K, $T_\infty$ at 5 km = 255.7 and $T_\infty$ at 10 km = 223.3 **(06 Marks)**

c. A supersonic airplane is flying at Mach 2 at an altitude of 16 km. Assume the shock wave pattern from the airplane quickly coalesces into mach wave that intersects the ground behind the airplane, causing a 'sonic boom' to be heard by a bystander on the ground. At the instant the sonic boom is heard, how far ahead of the bystander is the airplane? **(04 Marks)**

## PART – B

5 Write short notes on the following:

a. Simplified horse shoe vortex model.

b. Formation of flight.

c. Influence of downwash on tail place.

d. Ground effects. **(20 Marks)**

6 Deduce the following:

a. $-\frac{\tau+1}{V_\infty}\phi_x\phi_{xx}+\phi_{rr}+\frac{1}{r}\phi_r=0$ **(10 Marks)**

b. $R(x)\left(\frac{v_r}{V_\infty+u}\right)_c \approx \frac{(rv_r)_0}{V_\infty} = R(x)\frac{dR(x)}{dx}$ **(10 Marks)**

7 a. What are high lift devices? List them and explain their effects on aerodynamic characteristics. **(10 Marks)**

b. Discuss the advantages of swept wings in modern airplanes. **(10 Marks)**

8 a. Derive and illustrate with a neat sketch of the boundary layer properties over a flat plate considering viscous flow. **(12 Marks)**

b. Derive the Navier-stokes equation for an unsteady, compressible, three-dimensional viscous flow. **(08 Marks)**

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