INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

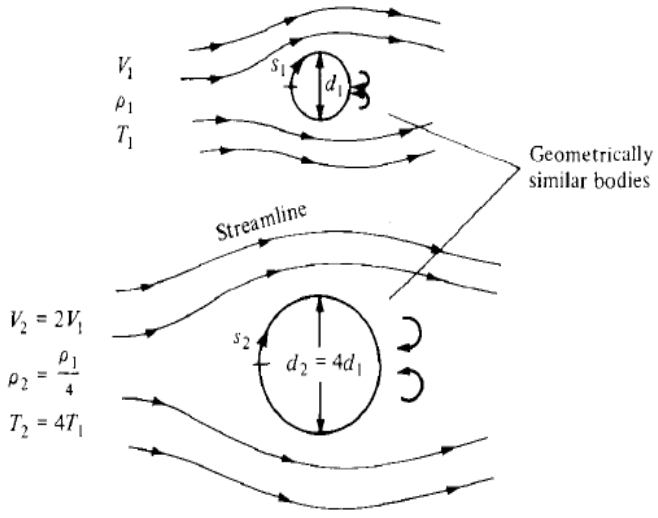
Course Name	:	**AERODYNAMICS - I**
Course Code	:	**A42102**
Class	:	II B. Tech II Semester
Branch	:	Aeronautical Engineering
Year	:	2016 – 2017
Course Coordinator	:	Dr. A. BARAI, Professor
Course Faculty	:	Dr. A. BARAI, Professor

OBJECTIVES

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education? The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited.

In line with this, Faculty of Institute of Aeronautical Engineering, Hyderabad has taken a lead in incorporating philosophy of outcome based education in the process of problem solving and career development. So, all students of the institute should understand the depth and approach of course to be taught through this question bank, which will enhance learner‟s learningprocess.

S.No	Questions	Blooms Taxonomy Level	Course Outcome
	UNIT – I **REVIEW OF FLUID MECHANICS**		
PART - A (Short answer questions)			
1	An airfoil is kept at 5 degrees angle of attack in a flow. The lift and drag coefficients are 3.0and 0.2 respectively. Find the normal and axial forces.	Evaluation	1
2	The normal force is acting at the quarter chord point. Find the moment on the airfoil at the leading edge of the airfoil.	Evaluation	2
3	Axial force and normal force are the only sources of generation of all types of changes on aircraft. Justify.	Evaluation	1
4	Define Lift and Drag. Also state the equations of coefficients of both.	Knowledge	3
5	Explain how lift generated.	Comprehension	4
6	State Continuity Equation and also represent the equation.	Analysis	1
7	State Momentum Equation and also represent the equation.	Analysis	2
8	State Buckingham pi theorem.	Application	3

S.No	Questions	Blooms Taxonomy Level	Course Outcome
9	Define mach number	Knowledge	4
10	Difference between inviscid and viscous flows	Knowledge	2
PART - B (Long answer questions)			
1	Derive the expression to estimate the lift coefficient.	Application	1
2	List out and explain the different types of flows.	Comprehension	2
3	Derive the differential form of continuity equation.	Analysis	3
4	Derive the differential form of momentum equation.	Analysis	4
5	Derive the integral form of continuity equation.	Evaluation	5
6	Derive the Navierstoke's equation.	Analysis	2
7	Derive Euler equation.	Evaluation	2
8	Derive coefficient of force, Reynolds number and mach number using	Evaluation	2
9	Discuss the importance of aerodynamics. Give historical examples.	Analysis	1
10	List out and explain all the fundamental variables of aerodynamics	Analysis	1
Part – C (Problem Solving and Critical Thinking)			
1	Derive the integral form and differential form of continuity equation	Analysis	1
2	Consider the supersonic flow over a 5° half-angle wedge at zero angle of attack.The freestream Mach number ahead of the wedge is 2.0, and the freestream pressure and density are 1.01 x 105 N/m2 and 1.23 kg/m3, respectively (this corresponds to standard sea level conditions). The pressures on the upper and lower surfaces of the wedge are constant with distance 5 and equal to each other, namely, $P_u = P_l = 1.31 \times 10^5$ N/m2.The pressure exerted on the base of the wedge is equal to P∞. The shear stress varies over both the upper and lower surfaces as $\tau_w = 431\ s^{-0.2}$. The chord length, c, of the wedge is 2 m. Calculate the drag coefficient for the wedge.	Analysis	2
3	Derive the integral and differential form of momentum equation.	Application	3
4	Consider the flow over two circular cylinders, one having four times the diameter of the other, as shown in Fig. 1.20. The flow over the smaller cylinder has a freestream density, velocity, and temperature given by ρ_1, V_1, and T_1respectively. The flow over the larger cylinder has a freestream density, velocity, and temperature given by ρ_2, V_2, and T_2, respectively, where $\rho_2 = \rho_1/4$, $V_2 = 2V_1$, and $T_2 = 4T_1$ • Assume that both μand $a$are proportional to $T^{1/2}$. Show that the two flows are dynamically similar. 	analysis	3

5	Derive NavierStokes's equation and Euler's equation and explain the basic difference between them.	Knowledge	2
6.	Describe in detail how the flows are classified according to their mach number.	Knowledge	2
7.	Explain the following flows: a) Incompressible and compressible b) Viscous and inviscid c) Continuum and free molecular flow d) Steady and unsteady	Knowledge	1
8.	Discuss the importance of aerodynamics with historical examples and explain all the fundamental variables of aerodynamics.	Knowledge	1
9.	Consider a circular cylinder in a hypersonic flow, with its axis perpendicular to the flow. Let ϕ be the angle measured between radii drawn to the leading edge	Analysis	1
10.	Derive expressions to estimate lift and drag coefficients.	Analysis	2

UNIT – II

INVISCID INCOMPRESSIBLE FLOWS

PART - A (Short answer questions)

S.No	Questions	Blooms Taxonomy Level	Course Outcome
1	Define Kelvin Circulation Theorem.	Comprehension	2
2	Define incompressible flow condition.	Analysis	3
3	State Laplace equation for a compressible and incompressible fluid.	Knowledge	4
4	D'alembert's paradox is between theoretical drag and real life drag. What does this paradox describes specifically?	Knowledge	1
5	Magnus effect creates the aerodynamic forces over spinning bodies. Justify the statement.	Comprehension	2
6	State stream and potential functions for doublet flow.	Analysis	5
7	What are the infinity boundary conditions?	Knowledge	3
8	Define source and sink flows.	Knowledge	2
9	Explain Kutta-conditions.	Comprehension	6

PART - B (Long answer questions)

1	Prove that the velocity potential and the stream function for a uniform flow satisfy Laplace's equation.	Comprehension	1
2	Explain the uniform flow and source flows with complete derivations.	Application	1
3	Derive the stream function and potential functions for the combination of uniform, doublet and vortex flows.	Evaluation	1
4	Derive the stream function and potential functions for doublet flow.	Evaluation	2
5	Wall boundary conditions and infinity boundary conditions exist for a flow over any object. Derive the conditions.	Comprehension	2
6	Define and derive irrotational and incompressible flow conditions.	Evaluation	3
7	Derive the stream function and potential functions for the combination of uniform and doublet flow.	Analysis	3
8	Define and explain Kelvin circulation theorem.	Application	4
9	Obtain the expression velocity potential and stream for an uniform flow in terms of Cartesian and polar co-ordinates.	Analysis	4
10.	Describe how the uniform flow and source flow develop flow over a semi-infinite body.	Knowledge	3

S.No	Questions	Blooms Taxonomy Level	Course Outcome
Part – C (Problem Solving and Critical Thinking)			
1	Explain in detail how combination of a uniform flow and doublet flow produces non lifting flow over a cylinder.	Application	1
2	Derive the streamfunction and velocity potential for source and sink pair.	Evaluation	2
3	Derive the streamfunction and velocity potential for uniform flow and doublet flows.	Knowledge	2
4	Explain in detail how combination of uniform flow, doublet flow and vortex flow produces lifting flow over a cylinder.	Comprehension	2
5	Explain the KuttaJoukowsky theorem and Kelvin circulation theorem.	Application	2
6.	Explain with sketch the thin aerofoil theory.	Analysis	1
7.	Explain in detail, resolution of thin airfoil problem into non lifting cases and their solutions.	Knowledge	1
8.	Explain in detail, resolution of thin airfoil problem into lifting cases and their solutions.	Analysis	4
9.	Explain in detail all the elementary flows and their combinations.	Analysis	7
10.	Discuss in detail the aerodynamics of spinning tennis ball.	Analysis	6
UNIT – III **VISCOUS FLOW AND BOUNDARY LAYER**			
PART - A (Short answer questions)			
1	Draw and explain the temperature profile	Knowledge	2
2	Define displacement thickness	Knowledge	1
3	Define boundary layer thickness	Comprehension	3
4	Discuss the patching of inviscid external flow and viscous boundary layer flow	Comprehension	4
5	Draw the boundary layer velocity profile	Knowledge	6
6	Define momentum thickness	Analysis	7
7	What is adverse pressure gradient?	Application	3
8	What is favorable pressure gradient	Analysis	2
9	What are the boundary layer boundary conditions?	Knowledge	1
10	Write down the effects of transition on aerofoils.	Knowledge	1

S.No	Questions	Blooms Taxonomy Level	Course Outcome
PART - B (Long answer questions)			
1	Derive skin friction drag by integration of tangential and pressure drag by	knowledge	2
2	Explain the boundary layer growth along a flat surface	Analysis	1
3	Explain in detail momentum thickness and displacement thickness.	Application	2
4	Discuss in detail laminar, transition and turbulent flows	Analysis	1
5	Derive the boundary layer equations	Comprehension	2
6	Derive the Blassius solution for flat plate problem	comprehension	1
7	Discuss in detail the flow separation phenomena.	Knowledge	3
8	Describe the flow past circular cylinder at different Reynolds number	Knowledge	2
9	Discuss the effect of transition and surface roughness on airfoil	Comprehension	3
10	Derive the Von Karman's momentum equation.	Comprehension	1
Part – C (Problem Solving and Critical Thinking)			
1	What is skin friction drag? Discuss the importance of skin friction drag for airfoils.	Knowledge	2
2	Explain the boundary layer growth along a flat surface and discuss in detail laminar, transition and turbulent flows	Knowledge	3
3	Derive skin friction drag by integration of tangential and pressure drag by integration of normal stresses respectively and explain the importance of skin friction drag for aerofoils.	Knowledge	1
4	Explain in detail variation of drag coefficient with Reynolds number for Circular cylinder.	Application	4
5	Explain boundary layer separation and the factors that influence boundary layer separation.	Analysis	2
6	Derive the Prandtl's boundary layer equations and derive the blassiussolution.for the flat plate problem.	Analysis	3
7	Some engineers wish to obtain a good estimate of the drag and boundary-layer thickness at the trailing edge of a miniature wing. The chord and span of the wing are 6mm and 30mm respectively. A typical flight speed is 5m/s in air (kinematic viscosity = 15 x 10^{-6} m^2/s, density = 1.2 kg/m^3). They decide to make a superscale model with chord and span of 150 mm and 750 mm respectively. Measurements on the model in a water channel flowing at 0.5m/s (kinematic viscosity = 1x$10^{-6}$$m^2/s$, density = l000 kg/m^3) gave a drag of 0.19N and a boundary-layer thickness of 3 mm. Estimate the corresponding values for the prototype.	Application	5
8	Consider Mach 4 flow at standard sea level conditions over a flat plate of chord 5 in. Assuming all laminar flow and adiabatic wall conditions, calculate the skin friction drag on the plate per unit span.	Comprehension	6
9	The wing on a Piper Cherokee general aviation aircraft is rectangular, with a span of 9.75 m and a chord of 1.6 m. The aircraft is flying at cruising speed (141 mi/h) at sea level. Assume that the skin friction drag on the wing can be approximated by the drag on a flat plate of the same dimensions. Calculate the skin friction drag: (a) If the flow were completely laminar (which is not the case in real life) (b) If the flow were completely turbulent (which is more realistic). Compare the two results.	Analysis	7
10	What is momentum integral equation? Derive the Von Karman's momentum equation	Comprehension	3

S.No	Questions	Blooms Taxonomy Level	Course Outcome
	UNIT – IV **INVISCID FLOW OVER WINGS & PANEL METHODS**		
PART - A (Short answer questions)			
1	Define induced drag.	Knowledge	1
2	State Biot-Savart Law.	Knowledge	1
3	Explain starting vortex.	Knowledge	`1
4	Explain the formation of trailing vortices.	Analysis	2
5	Explain bound vortex.	Knowledge	3
6	State the vortex filament statement of Helmholtz's vortex theorem.	Knowledge	4
7	What is downwash?	Analysis	2
8	What is source panel method?	Analysis	3
9	What is vortex panel method?	Analysis	2
10	Write the expression for induced drag.	Application	2
PART - B (Long answer questions)			
1	Consider a vortex filament of strength Γ in the shape of a closed circular loop of radius R. Obtain an expression for the velocity induced at the center of the loop in terms of Γ and R.	Analysis	1
2	Consider the same vortex filament as mentioned in the problem above. Consider also a straight line through the center of the loop, perpendicular to the plane of the loop. Let A be the distance along this line, measured from the plane of the loop. Obtain an expression for the velocity at distance A on the line, as induced by the vortex filament.	Analysis	1
3	The measured lift slope for the NACA 23012 airfoil is 0.1080 degree^{-1}, and α_{L0}=-1.3°. Consider a finite wing using this airfoil, with AR = 8 and taper ratio = 0.8. Assume that $\delta = \tau$. Calculate the lift and induced drag coefficients for this wing at a geometric angle of attack = 7^0.	Analysis	2
4	Explain starting, bound and trailing vortices of wings.	Knowledge	2
5	Explain in brief Lanchester's experiment.	Analysis	1
6	Explain in detail Prandtl's lifting line theory.	Analysis	4
7	Derive the expression for induced drag and minimum induced drag for elliptic platform.	Evaluation	4
8	Explain the source and vortex panel methods	Knowledge	3
9	Explain in detail vortex filament statement of Helmholtz's vortex theorems.	Knowledge	3
10	Explain elliptic loading and wings of elliptic platform.	Knowledge	1
Part – C (Problem Solving and Critical Thinking)			
1	Explain in detail vortex filament statement of Helmholtz's vortex theorems Biot Savart Law.	Knowledge	2
2	Explain in brief Lanchester's experiment and Prandtl's lifting line theory.	Application	2
3	Explain elliptic loading & wings of elliptic platforms. Derive the expression for	Analysis	1
4	Explain in detail the use of quarter chord and three- quarter chord points in	Knowledge	1
5	a) Lifting surface theory predicts better lift distribution on a wing with a low aspect ratio and of any type of given planform. Demonstrate the verification of the statement. b) Compare the formulation in (a) above with that in the classical lifting line theory with details.	Analysis	4
6	How does a source panel method differ from a vortex panel method and what conditions? Hence describe the formulation of a source panel method for a non-lifting flow over a circular cylinder.	Knowledge	3

7	A constant strength vortex panel of strength 50 units is located on the axis from X1=3.5 to X2=6.65. Determine the influence of this vortex panel at a point P (4.5, 4.5) to evaluate V (u, w). Develop the expressions used for determining Velocity potential.	Application	2
8	The Piper Cherokee (a light, single-engine general ayiation aircraft) has a wing area of 170 ft2 and a wing span of 32 ft. Its maximum gross weight is 2450 lb. The wing uses an NACA 65-415 airfoil, which has a lift slope of 0.1033 degree^{-1} and $\alpha_{L=0}$ = -3°. Assume τ = 0.12. If the airplane is cruising at 120 mi/h at standard sea level at its maximum gross weight and is in straight-and-level flight, calculate the geometric angle of attack of the wing.	Evaluation	2
9	Consider the airplane and flight conditions given above. The span efficiency factor e for the complete airplane is generally much less than that for the finite wing alone. Assume e = 0.64. Calculate the induced drag for the airplane in the above problem.	Evaluation	5
10	Explain starting, bound and trailing vortices of wings and explain the formation of them.	Evaluation	6
	UNIT – V **APPLIED AERODYNAMICS ANDINTRODUCTION TO PROPELLERS**		
PART - A (Short answer questions)			
1	Define critical mach number.	Knowledge	2
2	What is meant by drag divergence?	Analysis	2
3	Define drag reduction.	Knowledge	1
4	List out lift augmentation methods.	Analysis	1
5	Explain how flaps augment the lift production.	Analysis	3
6	Define advance ratio.	Knowledge	4
7	Explain how to read propeller chart.	Application	5
8	Define efficiency.	Knowledge	6
9	Define torque coefficient.	Knowledge	3
10	Explain the working of vortex generators.	Analysis	2
PART - B (Long answer questions)			
1	Explain in detail how sweep, winglets and flaps are used for lift augmentation.	Comprehension	2
2	Explain the working of vortex generators and slap and discuss how they are used for lift augmentation	Comprehension	1
3	Define the following terms: a) Critical mach number b) Drag divergence c) Efficiency d) Torque coefficient e) Drag reduction	Knowledge	2
4	Explain in detail how to read propeller chart	Knowledge	2
5	Explain actuator disk theory due to Rankine &Froude power& thrust coefficients.	Knowledge	3
6	Why the propeller is twisted by blade element analysis blade angle? Explain.	Analysis	1
7	Explain the concept of slip stream with only axial velocity.	Knowledge	4
8	Explain in detail advance ratio and torque coefficient	Knowledge	4
9	Compare the role of winglets and slats in lift augmentationn	Analysis	1
10	What are vortex generators? Explain how they are employed to augment the lift production.	Knowledge	6

S.No	Questions	Blooms Taxonomy Level	Course Outcome
Part – C (Problem Solving and Critical Thinking)			
1	What is lift augmentation? Explain in detail how sweep, winglets and flaps are used for lift augmentation.	Knowledge	1
2	Explain the need for lift augmentation and explain how vortex generators and slap can be used for that purpose.	Knowledge	2
3	Define and explain the following terms in detail: a) Critical mach number b) Drag divergence c) Torque coefficient d) Efficiency e) Drag reduction f) Thrust coefficient g) Lift augmentation	Knowledge	3
4	Explain the concept of slip stream with only axial velocity and Explain in detail how to read propeller chart	Evaluation	1
5	Explain in detail the actuator disk theory due to Rankine &Froude power& thrust coefficients.	Evaluation	2
6	a) Why the propeller is twisted by blade element analysis blade angle? Explain. b) Explain the concept of slip stream with only axial velocity.	Application	2
7	What are vortex generators and slats? Explain how they are employed to augment the lift production.	Analysis	3
8	What are flaps? What are the different types of flaps? Explain how they are employed to augment the lift production.	Knowledge	1
9	What are winglets? Explain their usage in aircrafts in detail.	knowledge	4
10	a) Explain the effect of sweep in lift augmentation. b) Explain in detail advance ratio and torque coefficient.	Knowledge	3

Prepared by: Dr. A. BARAI,Professor

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