INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

DEFINITIONS AND TERMINOLOGY

Course Name	:	**AERODYNAMICS**
Course Code	:	AAEB10
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Branch	:	**AERONAUTICAL ENGINEERING**
Section	:	
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Course Faculty	:	Dr. P K Mohanta, Professor Department of Aeronautical Engineering

OBJECTIVES

I	To help students to consider in depth the terminology and nomenclature used in the syllabus.
II	To focus on the meaning of new words / terminology/nomenclature

DEFINITIONS AND TERMINOLOGYQUESTION BANK

S No	QUESTION	ANSWER	Blooms Level	CO	CO Code
UNIT - I					
1	Define incompressible flow.	Flow in which density remains constant is defined as incompressible flow. For air flow upto Mach number 0.3 can be assumed to be incompressible.	Remember	CO 1	CAAE004.01
2	Define Mach number (M).	Mach number is defined as the ratio of speed of object to the local speed of sound in the medium that object is moving.	Understand	CO 1	CAAE004.01
3	Define potential flow.	Inviscid, incompressible and irrotational flow is defined as potential flow.	Remember	CO 1	CAAE004.01
4	Define streamline.	An imaginary line in which velocity vector at any point is normal to the line is defined as streamline.	Understand	CO 1	CAAE004.01
4	Define compressible flow.	Flow in which the density changes with speed is called compressible flow.	Remember	CO 1	CAAE004.02
5	What is stream function?	A fuction which give velocity field of flow upon differentiating it is known as stream fuction.	Remember	CO 1	CAAE004.04
6	What is the condition for rotational and irrotational flow?	If $\nabla \times V \neq 0$ at every point in a flow, the flow is called rotational. This implies that the fluid elements have a finite angular velocity. If $\nabla \times V = 0$ at every point in a flow, the flow is called irrotational. This implies that the fluid elements have no angular velocity; rather, their motion through space is a pure translation.	Understand	CO 1	CAAE004.04
7	Define source.	A flow in which streamlines are straigtlines, orginating from a center point and velocity varies inversly proportional to the distance is defined as source flow.	Remember	CO 1	CAAE004.03
8	Define strenth of source.	it is defined as the rate of volume flow from the source, per unit depth in perpendicular direction.	Remember	CO 1	CAAE004.03
9	Define vortex flow.	A flow field in which streamlines are concentric circle and velocity varies inversly proporstional to distance, but remains constant along the streamline is defined as vortex flow.	Remember	CO 1	CAAE004.04
10	Define doublet.	A special degenrate case of source-sink combination that leads to singularity is called doublet.	Remember	CO 1	CAAE004.04
12	What is Rankine oval?	A finite limit solid body formed by superimposition of source, sink and uniform flow is kown as Rankine oval.	Understand	CO 1	CAAE004.04

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13	What is Magnus effect?	The production of resultant upward or downward normal force due to rotation of circular cylinder is known as magnus effect.	Remember	CO 1	CAAE004.04
14	What is D'Alemberts paradox?	The uniform flow over stationary cylinder results in zero lift and drag. In practical zero lift case is possible, wheras zero drag is not possible. The paradox between theoritical and experimental results is called D'Alemberts paradox.	Understand	CO 1	CAAE004.04
15	What is Kutta-Joukowski theorem?	It states that for the lifting flow over cylinder, the lift per unit span is directly proprtional to circulation.	Remember	CO 1	CAAE004.03
UNIT – II					
1	Define airfoil.	A streamlined body which offers minimum drag and maximum lift (maximum aerodynamic efficiency $(L/D)_{max}$) is defined as airfoil.	Understand	CO 2	CAAE004.04
2	What is mean by camber line?	It is the locus of center of circles drawn between upper surface and lower surface.	Remember	CO 2	CAAE004.04
3	What is camber of an airfoil?	The camber is the maximum distance between the mean camber line and the chord line, measured perpendicular to the chord line.	Remember	CO 2	CAAE004.04
4	What is aerodynamic center?	A point in the chord line of an airfoil about which the aerodynamic moment is constant irrespective of angle of attack is known as aerodynamic center.	Remember	CO 2	CAAE004.05
5	Define Center of pressure.	A point in the chord line of an airfoil the resultant pressure force act is known as center of pressure. (Or) A point at which aerodynamic moment is zero is called center of pressure.	Remember	CO 2	CAAE004.05
6	What are all the assumptions made for thin airfoil theory?	1. Airfoil is thin $\eta << c$ 2.Angles/slopes are small e.g. $\sin\alpha \approx \alpha$, $\cos\alpha \approx 1$, slope $\approx$ angle. 3. Airfoil only slightly disturbs free stream $u', v' << V_\infty$	Understand	CO 2	CAAE004.04
7	What is angle of attack (α)?	The acute angle between the chord of an airfoil and velocity vector of relative airflow is called angle of attack.	Remember	CO 2	CAAE004.04
8	Define zero-lift angle of attack of an airfoil.	The angle of attack for which the resultant upward force i.e lift is zero is defined as zero-lift angle of attack($\alpha_{CL=0}$)	Understand	CO 2	CAAE004.05
9	Define thickness of an airfoil.	It is the maximum distance between upper surface and lower surface of airfoil measured perpendicular to chord.	Remember	CO 2	CAAE004.05

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10	Define angle of inidence.	On fixed-wing aircraft, the angle of incidence (sometimes referred to as the mounting angle) is the angle between the chord line of the wing where the wing is mounted to the fuselage, and a reference axis along the fuselage.	Remember	CO 2	CAAE004.06
11	What is aerodynamic stall?	A stall is a condition in aerodynamics and aviation when the angle of attack increases beyond a certain point, the lift begins to decrease due to flow seperation. The angle at which this occurs is called the critical angle of attack.	Understand	CO 2	CAAE004.06
12	What are high-lift devices?	A high-lift device is a component or mechanism on an aircraft's wing that increases the amount of lift produced by the wing. The device may be a fixed component, or a movable mechanism which is deployed when required.	Remember	CO 2	CAAE004.07
13	What are all the different types of high-lift devices?	Common movable high-lift devices include wing flaps and slats. Fixed devices include leading-edge slots, leading edge root extensions, and boundary layer control systems.	Remember	CO 2	CAAE004.07
14	What are all the steps invoved in stall recovery?	The key factor in recovery from a stall is regaining positive control of the aircraft by reducing the angle of attack. At the first indication of a stall, the wing angle of attack must be decreased to allow the wings to regain lift. Every aircraft in upright flight may require a different amount of forward pressure to regain lift. The next step in recovering from a stall is to smoothly apply maximum allowable power to increase the airspeed and minimize the loss of altitude. As airspeed increases and the recovery is completed, power should be adjusted to return the aeroplane to the desired flight condition. Straight and level flight should then be established with full co-ordinated use of the controls.	Remember	CO 2	CAAE004.07
15	What is stall speed?	Stall speed is slowest speed a plane can fly to maintain level flight. Stall speed can be increased by increasing the lift coefficient of airfoil.	Remember	CO 2	CAAE004.07
UNIT – III					
1	Define induced drag.	Induced Drag is an inevitable consequence of lift and is produced by the passage of an aerofoil (e.g. wing or tailplane) through the air.	Remember	CO 3	CAAE004.08
2	What is the reason for formation of wing tip vortices?	Air flowing over the top of a wing tends to flow inwards because the decreased pressure over the top surface is less than the pressure outside the wing tip. Below the wing, the air flows outwards because the pressure below the wing is greater than that outside the wing tip. the streams of air from above and below the wing are flowing at an angle to each other as they meet	Understand	CO 3	CAAE004.08

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		along the trailing edge of the wing. They combine to form vortices which, when viewed from the rear, rotate COckwise from the left wing and counter COckwise from the right			
3	What are the methods to reduce induced drag?	Induced drag can be reduced by inroducing wing tapper, increasing aspect ratio, introducing wing twist and attaching winlets at the tip of wing.	Remember	CO 3	CAAE004.08
4	What is downwash?	Downwash is the air that is deflected by flowing around an airfoil. This airfoil can be the wing of a plane, the rotor of a helicoptor or a propeller on a plane.	Remember	CO 3	CAAE004.08
5	Define vortex sheet.	A vortex sheet is a term used in fluid mechanics for a surface across which there is a discontinuity in fluid velocity, such as in slippage of one layer of fluid over another.	Understand	CO 3	CAAE004.08
6	Define vortex line and tube.	A vortex line is a line whose tangent is everywhere parallel to the local vorticity vector. The vortex lines drawn through each point of a COsed curve constitute the surface of a vortex tube	Remember	CO 3	CAAE004.08
7	What is the effect of wing tapper?	Tapered wings increase the aspect ratio of the wing (length to chord width) improving lift. The smaller tip also decreases induced drag by reducing the size of wingtip vortices where the lower air mixes with the upper surface air.	Remember	CO 3	CAAE004.09
8	What is the effect of wing twist?	Twist is applied to wings so that the outboard section of the wing does not stall first. When an aircraft is pitching nose up and increasing its angle of attack, the airflow over the wing eventually reaches a point where it becomes turbulent, causing a loss in lift. By twisting the outboard portion of the wing down, the stall is delayed in that area, simply because the angle of attack is lower in that region.	Remember	CO 3	CAAE004.09
9	Define aerodynamic twist.	Aerodynamic twist is defined as "the angle between the zero-lift angle of an airfoil and the zero-lift angle of the root airfoil." In essence, this means that the airfoil of the wing would actually change shape as it moved farther away from the fuselage. Typically the zero-lift line is rotated downward toward the wing tips, similar to geometric twist.	Remember	CO 3	CAAE004.09
10	What is the effect of sweep back wing?	Wing sweep has the effect of delaying the shock waves and accompanying aerodynamic drag rise caused by fluid compressibility near the speed of sound,by increasing the critical Mach nuber	Understand	CO 3	CAAE004.10
12	What is the advantage of delta wing?	The primary advantage of the delta wing is that, with a large enough angle of rearward sweep, the wing’s leading edge will not contact the shock wave	Remember	CO 3	CAAE004.10

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		boundary formed at the nose of the fuselage as the speed of the aircraft approaches and exceeds transonic to supersonic speed.			
13	What are the limitations of delta wing?	1. Lift induced drag is very high in subsonic conditions. 2. Maneuverability at supersonic speeds is restricted. 3. Very high landing speeds and bad field performance by tailless deltas.	Understand	CO 3	CAAE004.10
14	Define circulation.	Circulation is a scalar quantity defined as the line integral of the velocity field along a COsed contour.	Remember	CO 3	CAAE004.11
15	Define starting vortex	The starting vortex is a vortex which forms in the air adjacent to the trailing edge of an airfoil as it is accelerated from rest in a fluid	Remember	CO 3	CAAE004.11
UNIT - IV					
1	Define Interference drag	Interference Drag is drag that is generated by the mixing of airflow streamlines between airframe components such as the wing and the fuselage, the engine pylon and the wing.	Remember	CO 4	CAAE004.12
2	Parasite drag	It is the sum of skin-friction and pressure drag for an aircraft	Remember	CO 4	CAAE004.12
3	Define wing-body interaction	The lift of a wing-body combination is not obtained by simply adding the lift of the wing alone to the lift of the body alone. Rather, as soon as the wing and body are mated, the flow field over the body modifies the flow field over the wing, and vice versa-this is called the wing-body interaction.	Remember	CO 4	CAAE004.12
4	Define wing-body Combination.	The mating of a wing with a fuselage is called a wing-body combination.	Understand	CO 4	CAAE004.13
5	Define zero-lift drag coefficient.	The zero-lift drag coefficient $CD_0$is a dimensionless parameter which relates an aircraft's zero-lift drag force to its size, speed, and flying altitude.	Remember	CO 4	CAAE004.12
6	Difine non lifting body.	A body produce very small amount of total lift produced by aircraft is called non lifting body. Fuselage is the example for non lifting body.	Understand	CO 4	CAAE004.13
7	What are the assumptions for formulating as a slender body?	Low slenderness ratio, $\frac{R(x)}{l}<<1$ Small angle of attack, $\alpha<<1$ Small ratio of body radius to length, , $\left\|\frac{dR(x)}{dx}\right\|<<1$	Remember	CO 4	CAAE004.13

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8	What is the effects of propeller stream on the wing ?	Experimental studies showed that when the wing/tail was under the effect of the slipstream (jet) from a propeller whose axis was fixed in the direction of the undisturbed wind, the rotation and the dynamic pressure changes in the jet resulted in a nonsymmetrical variation in the lift.	Remember	CO 4	CAAE004.13
9	Define critical Mach number.	the critical Mach number of an aircraft is the lowest Mach number at which the airflow over some point of the aircraft reaches the speed of sound,	Understand	CO 4	CAAE004.14
10	Define drag-divergence Mach number	The drag-divergence Mach number is the Mach number at which the aerodynamic drag on an airfoil or airframe begins to increase rapidly as the Mach number continues to increase.This increase can cause the drag coefficient to rise to more than ten times its low-speed value	Remember	CO 4	CAAE004.14
11	Define Whitcomb area rule.	The Whitcomb area rule, also called the transonic area rule, is a design technique used to reduce an aircraft's drag at transonic and supersonic speeds, particularly between Mach 0.75 and 1.2.	Remember	CO 4	CAAE004.14
12	Define form drag.	Form Drag, also known as Pressure Drag or Profile Drag, is the drag caused by the separation of the boundary layer from a surface and the wake created by that separation. It is primarily dependent upon the shape of the object.	Remember	CO 4	CAAE004.14
13	What is the effect of boundary layer seperation?	When the boundary layer separates, its displacement thickness increases sharply, which modifies the outside potential flow and pressure field. In the case of airfoils, the pressure field modification results in an increase in pressure drag, and if severe enough will also result in loss of lift and stall, all of which are undesirable. For internal flows, flow separation produces an increase in the flow losses, and stall-type phenomena such as compressor surge, both undesirable phenomena	Remember	CO 4	CAAE004.15
14	What is the reason for flow sepearation?	Flow separation occurs when the boundary layer travels far enough against an adverse pressure gradient that the speed of the boundary layer relative to the object falls almost to zero. The fluid flow becomes detached from the surface of the object, and instead takes the forms of eddies and vortices.	Understand	CO 4	CAAE004.15
15	Define boundary layer seperation.	Boundary layer separation is the detachment of a boundary layer from the surface into a broader wake. Boundary layer separation occurs when the portion of the boundary layer COsest to the wall or leading edge reverses in flow direction.	Remember	CO 4	CAAE004.15

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UNIT - V					
1	Define boundary layer.	It is a thin layer adjusant to the surface with in which velocity varies from zero to free stream value.	Remember	CO 5	CAAE004.15
2	Define boundary layer thickness.	The boundary layer thickness, δ, is the distance across a boundary layer from the walls to a point where the flow velocity has essentially reached the free stream velocity.	Remember	CO 5	CAAE004.16
3	Define critical Reynolds number	It is dfined as Reynolds number at which the flow of a fluid changes from laminar to turbulent.	Understand	CO 5	CAAE004.17
4	Define Reynolds number.	The Reynolds number (Re) is an important dimensionless quantity in fluid mechanics used to help predict flow patterns in different fluid flow situations. It is defined as ratio of inertia force to viscous force.	Remember	CO 5	CAAE004.17
5	What is the difference between laminar and turbulent boundary layers?	A laminar boundary layer is one where the flow takes place in layers, i.e., each layer slides past the adjacent layers. This is in contrast to Turbulent boundary layers where there is an intense agitation. In a laminar boundary layer any exchange of mass or momentum takes place only between adjacent layers on a microscopic scale which is not visible to the eye.	Remember	CO 5	CAAE004.16
6	Define displacement thickness.	The displacement thickness, δ* is the distance by which a surface would have to be moved in the direction perpendicular to its normal vector away from the reference plane in an inviscid fluid stream of velocity u_0 to give the same flow rate as occurs between the surface and the reference plane in a real fluid	Remember	CO 5	CAAE004.16
7	Define momentum thickness	The momentum thickness, θ is the distance by which a surface would have to be moved parallel to itself towards the reference plane in an inviscid fluid stream of velocity u_0 to give the same total momentum as exists between the surface and the reference plane in a real fluid.	Remember	CO 5	CAAE004.20
8	Define energy thickness	The energy thickness, $\delta_3$is the distance by which a surface would have to be moved parallel to itself towards the reference plane in an inviscid fluid stream of velocity u_0 to give the same total kinetic energy as exists between the surface and the reference plane in a real fluid.	Understand	CO 5	CAAE004.20

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9	Define shape factor.	It is the ratio of displacement thickness and momentum thickness. It is used to determine the natur of flow.	Remember	CO 5	CAAE004.17
10	Define lower critical Reynolds number	It is defined as the Reynolds number below which flow is completely laminar in nature.	Understand	CO 5	CAAE004.17
11	Define upper critical Reynolds number	It is defined as the Reynolds number above which flow is completely turbulent in nature.	Remember	CO 5	CAAE004.17
12	What is adverse pressure gradient?	An adverse pressure gradient occurs when the static pressure increases in the direction of the flow. Mathematically this is expressed as: $d P / d x > 0$ for a flow in the positive x-direction	Remember	CO 5	CAAE004.18
13	What is favorable pressure gradient?	Favorable pressure gradient occurs when the static pressure decreases in the direction of the flow. Mathematically this is expressed as: $d P / d x < 0$ for a flow in the positive x-direction.	Understand	CO 5	CAAE004.18
14	Define Prandtls mixing length.	The mixing length model is a method attempting to describe momentum transfer by turbulence Reynolds stresses within a Newtonian fluid boundary layer by means of an eddy viscosity. The model was developed by Ludwig Prandtl known as Prandtls mixing length.	Remember	CO 5	CAAE004.19
15	Define transition.	The process of a laminar flow becoming turbulent is known as laminar-turbulent transition.	Remember	CO 5	CAAE004.19

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