Things You Should Know By Now or Find Out Right Away – An Essential But By No Means Exhaustive List (AE Senior Yr; Fluids/Aerodynamics/GasDynamics)

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* What is a fluid?
* How are fluids different from solids?
* What is hydrostatic pressure?
* What is dynamic pressure?
*What is static pressure?
* What is "shear stress"?
* What is "Archimedes' Principle"?
* What is the Avodagro Number? What does it indicate?
* What is the "center of pressure" on an airfoil? Where is is located on an airfoil in low-speed flow, does it depend on airfoil geometry, and if so, how?
* A Pitot tube is used to measure the stagnation pressure in an air stream where the flow speed is 10m/s. Given that the static temperature is 280K, and the static pressure is 101300 N/m2, find the stagnation pressure at the probe tip.
* What is "incompressible flow"? An airplane is flying at 500 mph at 30000 feet. Would you consider this to be an incompressible flow situation? Why?
* Why does the density of the atmosphere decrease as you go up?
* What is the "divergence theorem"? What has this got to do with fluid mechanics?
* What is a vector? Is hydrostatic pressure a vector or a scalar? What about velocity? temperature? density?
* What is a "stream function"? What is "two-dimensional flow"?
* What are "streamlines"?
* Two lines AB and CD, intesect at point E. Can these be streamlines? Why?
* Consider the flowfield within 0.1mm of the surface of the wing of a Boeing 727 under cruise conditions. Is this a "potential flow"? Why?
Consider the flowfield 0.5 above the wing of a Boeing 787 under cruise conditions. Can this be treated as potential flow? Why?
* Can you predict the drag of an airfoil using potential theory? Why?
* What good is potential flow theory?
* Can you write a potential function for the flow in the boundary layer of a flat plate?
* State Helmholtz's vortex theorems.
* What is "local acceleration"? What is "convective acceleration"?
* Write down Bernoulli's equation for incompressible flow
* Does the relation between static and stagnation pressure in a compressible flow conform to the same equation?
* Is the “q” the same as the difference between static and stagnation pressure in a flow at Mach 0.2? How about at Mach 2.3? Why?
* What is "Laplace's equation"?
* What is a “body of revolution”?
* What is the Kutta condition? What is it used for?
* What is a source panel?
* Given a vortex sheet, how would you find the velocity jump across it?
* What are the "boundary layer approximations"?
* What is the v-momentum equation for an incompressible laminar boundary layer, in the 2D Cartesian coordinate system where x is along the surface and y is perpendicular to the surface
* What is Reynolds number?
* A circular cylinder of radius 10mm is moved at a speed of 10m/s through air at standard sea-level conditions. What is the Reynolds number based on cylinder diameter? Do you expect the boundary layer on the cylinder to be laminar or turbulent? How would you estimate the force

required to keep the cylinder moving at a constant velocity of 10 m/s? What do you think will happen if the cylinder is made to start spinning about its axis while it is moving?
* You have to design a flat plate surface which will be exposed to high speed flight. If the Mach number is expected to reach about 0.8 at sea-level, what is the approximate value of the highest surface temperature to be expected? Assume that there is a layer of insulating material right below the flat plate, so that very little heat is conducted away.
* What is the first law of thermodynamics?
* What is the second law of thermodynamics? What is entropy? What is enthalpy?
* What is "elliptic loading" on a wing? Why is this desirable / undesirable?
* A co-op designs a jet engine using isentropic flow equations and claims that his engine will produce a net thrust of 30,000 lbs at sea level. Will the actual thrust be greater or less? Why?
* Why do people use the Laplace equation in aerodynamics when we all know that the full Navier-Stokes equations are more exact?
* How do you solve the Laplace equation for the flowfield around an airfoil?
* What is a perfect gas?
* Why are shocks formed in supersonic flows and not in fully subsonic flows?
* Why are diverging ducts used to accelerate supersonic flows, and converging ducts to accelerate subsonic flows?
* How is a Mach angle different from a shock angle? Calculate Mach angle at Mach 2.
* Plot the static pressure, velocity, stagnation pressure, static temperature and stagnation temperature changes across a normal shock.
* Why is a shock called a "wave"? What happens to the gas molecules at a particular point in still air is a shock passes across them? Will they stay unaffected? Will they move with the shock, or away from the shock, and if so, how fast? Will their speed of random motion be affected in any way? Will the number of molecules per unit volume change?
* Plot the section lift coefficient as a function of angle of attack for a 2-D, low-speed, symmetric airfoil. Also plot the lift coefficient versus angle of attack for a 3-D rectangular wing with a symmetric section (incompressible flow). What is the slope of this line? Why, physically, are the two slopes similar / different? What happens when the angle of attack gets large?
* What is a lifting line? A trailing vortex sheet?
* Define induced and effective angles of attack for a wing section.
* What is induced drag? What does its magnitude depend on?
* Prove that the speed for minimum drag occurs when the induced drag coefficient is equal to the coefficient of lift-independent drag.
* Is Mach number behind a normal shock greater or less than 1? How about an oblique shock?
* Describe changes in static and stagnation pressure as an inviscid flow traverses a Prandtl-Meyer expansion.
* Does a shock "reflect" from a solid wall as a shock, or as an expansion? How about a shock encountering a free surface?
* Calculate the speed of sound at the surface of the planet Xylon (pressure: 0.1 million Newtons per square meter) where the atmosphere is 100% Xenon and the temperature is 400K.
* Calculate the section lift coefficient of a thin symmetrical airfoil of chord 1.2 m at 5 degrees angle of attack at a velocity of 30 m/s at 10 km altitude on a standard day above Earth.
* What is the effect of increasing aspect ratio on the drag of a wing in incompressible flow?
* Calculate the maximum turning angle through a Prandtl-Meyer expansion from Mach 3.0.
* Calculate the induced velocity at a point on the lifting line located 20 feet away from a vortex shed from a point on the wing where the lift per unit span changes from 20N/m to 30 N/m suddenly. The flight speed is 50 m/s at standard sea level conditions.
* Calculate the pressure coefficient at a point on the wing where the velocity is 2.5 times the freestream value.
* Sketch the streamline pattern in the logitudinal section through the flow over a conical missile nose flying horizontally at Mach 2.
* What is meant by the term "strong oblique shock solution"?
* How (in words) would you derive the Glauert Solution to the "monoplane equation" in incompressible flow?

* What is the stagnation pressure at a missile nose at Mach 0.8 at 10km pressure altitude if the Prandtl number is 0.78?
* How (in words) do you derive the normal shock relations?
* Estimate the oblique shock angle for a turn of 2 degrees at Mach 2.45.
* Consider the flow at the exit of a slightly underexpanded 2-D nozzle. The exit-plane pressure is 1.07 times the outside pressure, and the Mach number is 2.0. a) sketch the flow patterns through deceleration to subsonic velocity. b) calculate the distance downstream of the exit where the first disturbance waves converge at the plane of symmetry, in terms of the values of the nozzle height H and discuss any other essential parameters.
* Derive the full potential equation, and the linearized equations, for steady compressible flow.
* A 5% thick airfoil placed at A degrees angle of attack produces a pressure coefficient of - 0.3 at a given chordwise location X at a freestream Mach number of 0.5. Find the thickness of an airfoil of the same family required to given the same pressure coefficient at the same chordwise location at Mach 0.75.
* What method would you use to analyze the lift and induced draq of a tapered, twisted wing of aspect ratio 8 at low angle of attack, in incompressible flow? How would you modify the results above, for a Mach number of 0.5?
* What method would you use to analyze the lift and induced draq of a highly swept, cambered wing, of aspect ratio 1.8 at low angle of attack, in incompressible flow? How would you modify the results above, for a Mach number of 0.5?
* What method would you use to analyze the lift and induced draq of a highly swept, cambered wing, of aspect ratio 1.8 at low angle of attack, at Mach 0.5? Do you need to modify your answer to the above two questions based on this?
* Can lifting line theory give you the pitching moment variation of a finite wing with angle of attack? How?
* Can slender wing theory be used to find the pressure drag of a finite wing? Why / How?
* How do you find the wave drag of a supersonic airfoil section?
* How do you find the laminar skin friction drag of an airfoil in incompressible flow?
* How do you find turbulent skin friction on a flat plate in incompressible flow?
* How do you find the skin friction drag of a wing in supersonic flow?
* What is a Sears-Haack body?
* What is a Karman Ogive?
* A supersonic air flow has a freestream Mach number of 2.0. What is the maximum expansion turning angle possible with this flow, if the static pressure cannot go below 1% of freestream pressure? What is the pressure coefficient at this point?
* Find the drag experienced due to a strip 0.1m wide of a flat-plate supersonic wing, at Mach 2.5. The upper surface is at zero angle of attack relative to the freestream, and there is no shock or expansion at the leading edge. The aircraft is flying at 40,000 feet ISA. The chord at this spanwise location is 30m.
* How does the above problem change if the wall is held at 250K by heat transfer to the fuel contained in the wing?
* How will you calculate the contour of an axisymmetric nozzle, with an area ratio of 80, for a gas of specific heat ratio 1.3 and molecular weight of 18?
* How will you predict the aerodynamic load distribution on a tapered, twisted wing of aspect ratio 8, at low angle of attack, at Mach 0.2? How about at Mach 0.7? How about at Mach 1.7?
* How are the linearized potential equations for steady supersonic and subsonic flow different?
* What is a "characteristic direction" in the above context?
* The critical Mach number of an airfoil is 0.8 for a given angle of attack. How much should the leading edge of a wing made of this airfoil be swept to bring the critical Mach number of the wing to 0.88?
* How will consideration of 3-D aerodynamics affect the answer to the above?
* Where does the idea that “ideal lift curve slope of an airfoil is 2*Pii “ come from?
* What happens to lift curve slope in low Reynolds number flow? Why?
* Can lifting line theory be used to find the pressure drag of a finite wing? Why / How?
* Given a 2-D velocity field, how would you decide if it can represent a physically possible flow?
* Calculate the speed of sound at 10,000 feet International Standard Altitude.

* A supersonic fighter passes 3000 meters above your head, going at Mach 1.4. Assuming that the temperature of the atmosphere is constant at 270K up to 3500 meters, estimate the time that you have, to cover your ears before the sound from the aircraft first hits them. How far will the fighter have gone in this time?
* What is the difference between an “equation” and an “identity”?
* What is the Oswatitsch Equivalence Rule? How does this help predict drag of a configuration?
* What are Newton's Laws of Motion?
* What is the continuity equation?
* What is pressure? Why does it occur in a gas?
* Derive the 1-D form of the steady-flow energy equation.
* A stagnation probe is placed in an air flow where the velocity is 200 m/s, static temperature is 500K, and static temperature is 1 atmosphere. What is the static enthalpy of the flow? What is the stagnation enthalpy? What have these things to do with the first law of thermodynamics?
* Two lines AB and CD appear to originate from the same point. Can these be streamlines? Why?
*What is stagnation pressure? What is total pressure?
*Why do airplanes have a non-zero “speed for minimum drag”? How do you predict that speed?
* Why does the pressure of the atmosphere decrease as you go up?
* How do you estimate the thrust of a rocket motor, given stagnation pressure and temperature, gas composition, and a conical nozzle with a 20 degree angle?
*How do you calculate the lift of a wing in supersonic flow?
* What is a thermal boundary layer? Is it the same thickness as the viscous boundary layer? Why?
* Is the friction coefficient for a turbulent boundary layer greater than or less than that for a laminar boundary layer? What is the approximate value of the ratio of the two in an incompressible flow?
* Sketch the chordwise variation of the pressure coefficient on the upper and lower surfaces of a cambered wing section if the wing is at moderate angle of attack at essentially incompressible flow conditions?
* What are the Hemholtz vortex theorems? What do they mean? Why do we care?
* How do you calculate the angle of attack required for a rectangular wing in order that it support a given aircraft in steady level flight?
* Prove that the tangential velocity component is unchanged across an oblique shock wave.
* Sketch the velocity profiles for a laminar and a turbulent boundary layer. Explain physically why they have different shapes.
* What is "boundary layer transition"? What factors influence the transition Reynolds number?
* Define Prandtl Number and Recovery Factor.
* What is a Blasius Profile? What assumptions are made in arriving at the solution for this profile?
* Explain the concepts of boundary layer displacement thickness and momentum thickness.
* What is the usefulness of the Karman Momentum Integral?
* Define friction coefficient.
* What are favorable and adverse pressure gradients? Contrast the behavior of a viscous boundary layer under the influence of each of these types of pressure gradient in turn.
* When tested in a low-speed tunnel, the pressure coefficient at the suction peak was -0.5. Find the critical Mach number.
* How is a "vortex sheet" similar to / different from a "shear layer"?
* What is the ideal lift curve slope of a symmetric thin airfoil in incompressible flow?
* What is the ideal lift curve slope of a rectangular wing of aspect ratio 10 in incompressible flow”
* Does the lift curve slope of an airfoil increase or decrease with Mach number in subsonic flow?
* What is the lift curve slope of an airfoil at Mach 2?
* Does the lift curve slope of an airfoil increase or decrease with supersonic Mach number ?
* How can air flow be called "incompressible" when everyone knows that air can be compressed?
* How can you increase the lift curve slope of an airfoil?
* How do you solve for the lift coefficient of a thick airfoil in incompressible flow?
* What is a boundary layer?
* What is the highest pressure on the blunt nose of the Space Shuttle at 10km pressure altitude if the Shuttle is flying at Mach 3?

* Define "circulation".
* What is "irrotational flow"?
* What is "Stokes theorem"?
* What is "potential flow"?