Transportation, Distribution & Logistics

Colorado CTE Course – Scope and Sequence

<table>
<tr><td>Course Name</td><td colspan="2">Aerodynamics</td><td>Course Details

Course = 0.50 Carnegie Unit Credit</td><td colspan="2">Credit = 0.5
Prerequisite: Introduction to Aviation and Aerospace
CTE Credential: CTE Transportation; CTE Transportation Operations; CTE STEM</td></tr>
<tr><td>Course Description</td><td colspan="5">This course studies the basic principles of aerodynamics, including airfoil shapes and aerodynamic forces, airplane performance, stability and control, strength limitations, and the application of these to specific flight situations. Included in this course are flight performance with airflow in the sub-, trans-, and supersonic envelope.
Federal Aviation Administration: https://www.faa.gov/regulations_policies/</td></tr>
<tr><td>Note:</td><td colspan="5">This is a suggested scope and sequence for the course content. The content will work with any textbook or instructional resource. If locally adapted, make sure all essential knowledge and skills are covered.</td></tr>
<tr><td>SCED Identification #</td><td>20053</td><td colspan="4">Schedule calculation based on 60 calendar days of a 90-day semester. Scope and sequence allows for additional time for guest speakers, student presentations, field trips, remediation, or other content topics.</td></tr>
<tr><td colspan="6">All courses taught in an approved CTE program must include Essential Skills embedded into the course content. The Essential Skills Framework for this course can be found at https://www.cde.state.co.us/standardsandinstruction/essentialskills</td></tr>
<tr><td>Instructional Unit Topic</td><td>Suggested Length of Instruction</td><td>CTE or Academic Standard Alignment</td><td>Competency / Performance Indicator</td><td>Outcome / Measurement</td><td>CTSO Integration</td></tr>
<tr><td>Principles of Flight</td><td></td><td>Understand characteristics of air and atmosphere on flight.</td><td>Student is expected to:
A) investigate basic aerodynamics principles;
B) investigate the forces of flight;
C) apply Newton's Three Laws of Motion to flight;
D) understand the impact of the Bernoulli Effect and Venturi Effect.</td><td>Analyze data to support the claim that Newton's Second Law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.</td><td></td></tr>
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Aircraft in Flight		Define basic aerodynamic forces acting on an aircraft. Define aerodynamic devices on an aircraft.	Student is expected to: A) investigate the basic parts and control surfaces on aircraft; B) investigate airplane stability; and C) explore concepts of pitch, roll, and yaw.	Examine the utilization of the airfoil, wings, tails and the propeller. Research industry manuals and course materials to explain the interrelationships among aerodynamics forces that affect an aircraft on the ground and in flight. Aerodynamic forces include, but are not limited to: ground effect, torque and P-factor, load factor, and aircraft stability. In addition, be able to explain the effects of frost, the significance of angle of attack as it relates to stalls and spins, and how load factors are affected by airplane turns.	
Lift and Drag		Understand the effect of airflow on an aircraft and its components using the laws of physics and fundamental mathematical methods.	Student is expected to: A) understand how friction relates to aerodynamics; B) define lift, thrust, and drag; C) compare static versus dynamic pressure.	Explain the concepts of lift versus weight and thrust versus drag. Apply flow similarity, non-dimensional coefficients such as the lift and drag coefficient, and non-dimensional parameters such as the Mach number and Reynolds number	

				in aerodynamic modeling of realistic configurations. Explain the sources of friction, induced, wave, and pressure drag.	
Kinematics		Apply mathematical calculations to solve aerodynamic-related equations.	Student is expected to: A) define the study of kinematics; and B) understand how kinematics is used to explain the motion of fluids and airflow.	Explain the motion and deformation of a fluid element using kinematics including the definition of shear strain, normal strain, vorticity, divergence, and the substantial derivative. Examine and perform calculations involving lift, drag, thrust and power in relation to various aspects of flight and aircraft performance.	
2-D Potential Flow and Panel Methods		Understand aerodynamic forces on an airfoil with respect to the geometry and configuration.	Student is expected to: A) Explain the basic elements (see Comment on basic elements below) of 2-D panel methods and 3-D vortex lattice methods. B) Explain the basic elements of coupled inviscid-	Explain the changes of aerodynamic forces on an airfoil with respect to the geometry and configuration by drawing related graphics.	

			viscous models for 2-D airfoils.		
Airfoils		Understand how an aircraft airfoil produces lift.	Understand the relationship between flow turning, the generation of lift on an airfoil, and the subsequent loss of lift upon stall. Student is expected to: A) explain the basic elements of thin airfoil potential flow models for 2-D subsonic and supersonic flows; and B) apply thin airfoil potential flow models.	Determine and calculate the aerodynamic forces that act on aerofoils and related aircraft surfaces at differing speeds. Apply integral momentum conservation and streamline curvature arguments to explain the relationship between flow turning, the generation of lift on an airfoil, and the subsequent loss of lift upon stall. Explain the basic elements of thin airfoil potential flow models for 2-D subsonic and supersonic flows. Apply thin airfoil potential flow models to estimate the forces on airfoils in 2-D subsonic and supersonic flows.	
Wings		Understand the generation and change of aerodynamic forces on finite wings.	Apply knowledge of aerodynamic forces on finite wings. Student is expected to: A) explain the basic elements of the lifting line model	Explain the basic elements of the lifting line model for high aspect ratio wings. Describe the dependence of lift and induced drag on geometry and performance parameters (e.g. aspect ratio,	

			for high aspect ratio wings; B) describe the dependence of lift and induced drag on geometry and performance parameters using the lifting line model; and C) apply the lifting line model to estimate lift, induced drag, and roll moments on high aspect ratio wings.	twist, camber distribution, wing loading, flight speed, etc.) using the lifting line model. Apply the lifting line model to estimate lift, induced drag, and roll moments on high aspect ratio wings.	
Compressibility and Shock Waves		Understand the effects of compressibility on lift and drag produced by an airfoil.	Student is expected to: A) understand the relationship between sound propagation and shock waves; B) define qualitative change in flow conditions across shocks and expansion fans; C) understand shock-expansion theory; D) understand how transonic drag rise and critical	Explain the relationship between sound propagation and shock waves. Describe the qualitative change in flow conditions (Mach number, pressure, temperature, total pressure, etc.) across shocks and expansion fans. Estimate the change in flow conditions across shocks and expansion fans using shock-expansion theory. Explain transonic drag rise including the critical Mach	

			Mach number are applied; and E) understand the relationship between wing sweep and drag.	number and the use of wing sweep to delay drag rise.	
Navier-Stokes		Understand how Navier-Stokes equations are used in aerodynamic modeling.	Student is expected to: A) Understand how the Euler and Navier-Stokes equations are applied to aerodynamic modeling.	Explain the basic elements of the finite volume approximation to the compressible Euler and Navier-Stokes equations. Explain how the Navier Stokes equations are used to model the weather, ocean currents, water flow, and air flow.	
Boundry Layers		Understand how boundry layers affect flight dynamics.	Student is expected to: A) Define the concept of a laminar boundary layer; B) Apply the integral boundary layer equations to describe the qualitative evolution of a laminar boundary layer; and C) Estimate friction drag on 2-D and	Explain the concept of a laminar boundary layer including the definition of the displacement thickness, the momentum thickness, and the skin friction coefficient, and the importance of the Reynolds number in determining the presence and behavior of a boundary layer. Apply the integral boundary layer equations to describe the qualitative evolution of a laminar boundary layer including separation and to quantitatively estimate the local thickness and skin friction.	

			3-D configurations.	Estimate friction drag on 2-D and 3-D configurations by decomposing the geometry into patches and assuming appropriate local values of skin friction coefficients including the possibility of laminar or turbulent boundary layer conditions.	
Turbulent Flow		Understand the basic behavior of boundary layers and turbulence.	Understand the basic behavior of boundary layers, and under what conditions they are prone to separation and transition to turbulence. Student is expected to: A) Explain the onset of turbulence in a boundary layer and the qualitative effects of turbulence on boundary layer evolution.	Explain the onset of turbulence in a boundary layer (i.e. transition) and the qualitative effects of turbulence on boundary layer evolution including the impact on velocity profile, skin friction coefficient, boundary layer thickness, and separation.	
Airfoil Design		Relate basic aerodynamic principles and practices regarding flight operations. Introduce various methods of aerodynamic testing and methodology related to wind	Investigate aerodynamic characteristics and basic aircraft performance issues. Student is expected to:	Explain the use of wind tunnel testing in aerodynamic modeling focusing on the importance of flow similarity in scale testing and on the typical corrections (e.g. wall	

		tunnels and the measurement of pressures, forces, moments, velocities.	A) Understand why wind tunnels are used in testing for aerodynamic modeling. B) Assess the ability and limitations of an aerodynamic model to estimate lift and drag (separated into friction, induced, wave, and pressure drag contributions) for a specific application.	corrections) required to simulate flight conditions. Contribute substantially as an individual to the design and execution of a computational and experimental aerodynamic analysis of realistic 3-D configuration together with members of a team (team project reports).	