SECTION 1.3 AERODYNAMICS (AD)

Unit 1.3.1 CADC: CPL aerodynamics – all aircraft categories

1. Reserved

2. Aerodynamics

2.1 Terminology

2.1.1 Explain the following terms and their effect on lift and drag production:

(a) aerofoil span, chord, camber, thickness/chord ratio;

(b) relative airflow and angle of attack;

(c) laminar and turbulent boundary layers.

2.1.2 Explain the different types of drag and state the effect on total drag resulting from changes in IAS, aircraft weight and height, if any.

2.2 Bernoulli's theorem and Coanda theory

2.2.1 Apply Bernoulli's theorem of constant energy flow to describe how an aerofoil produces lift, limited to the variation of kinetic energy (dynamic pressure) and potential energy (static pressure) as air flows through a venturi or over a aerofoil.

2.2.2 Explain Coanda theory and the effect on lift production.

2.3 Power requirements

2.3.1 Describe the power available and power required curves and best speeds for range and endurance, best rate of climb and best angle of climb.

2.4 Lift and drag

2.4.1 Explain the meaning of the following terms used in the lift and drag formulae viz:

(a) C_L and C_D – depend on shape and angle of attack of an aerofoil;

(b) $\frac{1}{2} \rho V^2$ – defines dynamic pressure (IAS);

(c) S – defines surface area.

2.5 Manoeuvres

2.5.1 Explain the forces of lift, weight, thrust and drag acting on an aircraft in the following cases:

(a) steady level flight;

(b) a steady climb;

(c) a steady descent;

(d) a balanced level turn.

2.6 Performance considerations

2.6.1 Give reasons for flying for maximum still air range and endurance.

2.6.2 Given that certain flight conditions remain constant, explain the effect of changes in headwind/tailwind component on level flight range and endurance.

2.6.3 List/identify aerodynamic and engine considerations which are required to achieve maximum still air range and endurance when operating an aircraft with the following types of engine:

(a) normally aspirated engine;

(b) turbocharged/supercharged engine.

2.6.4 From (theoretical) power required and power available graphs identify the following:

(a) best still air range speed;

(b) best endurance speed;

(c) maximum level flight speed.

Unit 1.3.2 CADA: CPL aerodynamics – aeroplane

1. Reserved

2. Aerodynamics

2.1 Changes in angle of attack

2.1.1 Explain the effect of changes in angle of attack up to the stalling angle on the following:

(a) pressure changes above and below an aerofoil;

(b) changes in airflow characteristics streamlined to turbulent;

(c) lift and drag;

(d) the boundary layer.

2.1.2 With reference to C_L, C_D, C_L/C_D graphs identify angles of attack associated with the following:

(a) minimum drag – maximum level flight speed;

(b) maximum lift – stalling angle;

(c) best C_L/C_D – best glide range and still air range.

2.2 Aerodynamic design features

2.2.1 Explain the purpose of the following design features/controls:

(a) anhedral dihedral aspect ratio sweepback wash-out;

(b) wing spoilers flaps vortex generators;

(c) trim tabs.

2.3 Lift and drag

2.3.1 With reference to C_L, C_D, C_L/C_D graphs, explain the angles of attack associated with the following:

(a) minimum drag – maximum level flight speed;

(b) maximum lift – stalling angle;

(c) best C_L/C_D – best glide range and still air range.

2.3.2 State the effect on total drag resulting from changes in IAS, aircraft weight and height.

2.4 Manoeuvres

2.4.1 Explain the relationship between speed, bank angle, radius and rate of turn during a balanced level turn.

2.4.2 For a given IAS, determine the approximate angle of bank to achieve a rate 1 turn (360^o in 2 minutes).

2.4.3 Explain the following:

(a) power must be applied to maintain speed in a level turn;

(b) an aeroplane tends to overbank in level and climbing turns and not in descending turns.

2.4.4 Explain the following:

(a) the effect of aileron drag on turn performance at low airspeed;

(b) how the following design features offset this drag:

(i) frise ailerons;

(ii) differential ailerons.

2.5 Performance considerations

2.5.1 Using power required and power available graphs, identify the following:

(a) stall speed (power on);

(b) the region of reverse command (sometimes described as the ‘back of the power curve’).

2.5.2 Describe the following terms and cite situations that may result in an aeroplane exceeding load factor and wing loading limits:

(a) load factor;

(b) ‘g’;

(c) wing loading.

2.5.3 Given that certain flight conditions remain constant, explain the effect of the following:

(a) changes in weight and altitude (height) on:

(i) angle of attack and IAS in level flight;

(ii) level flight range and endurance;

(iii) turn rate and radius;

(iv) glide range and endurance;

(b) changes in headwind/tailwind component on:

(i) glide range;

(ii) endurance;

(c) changes in power on turn rate and radius.

2.5.4 Explain how the energy state of an aircraft changes with changes in altitude and airspeed.

2.6 Stability and control

2.6.1 Explain the effect of the factors listed below on the stability and control of an aeroplane in each of the following 3 planes of movement:

(a) longitudinal stability:

(i) position of CG;

(ii) movement of centre of pressure;

(iii) changes in thrust;

(iv) tailplane moment;

(b) lateral stability:

(i) high versus low set wings;

(ii) dihedral versus anhedral;

(iii) sweepback;

(c) directional stability:

(i) large fore/aft displacement of the CG;

(ii) large versus small fin and rudder moment.

2.6.2 Describe the relationship between directional and lateral stability (spiral instability) and state the effect of spiral instability on the control of an aeroplane.

2.6.3 Recognise statements/diagrams which describe static and dynamic stability.

2.6.4 Describe the controllability problems associated with flight in the region of reverse command.

2.6.5 Explain the purpose of the following:

(a) trim tabs (fixed and cockpit controlled);

(b) balance tabs;

(c) anti-balance tabs;

(d) aerodynamic balance;

(e) mass balance.

2.6.6 Explain the function of the items mentioned in 2.6.5 in relation to the movement of a main control surface.

2.7 Taxi, take-off and landing

2.7.1 Describe the stability and control characteristics of nose wheel aeroplanes during ground operation.

2.7.2 Describe the result of the following factors on the controllability of an aeroplane:

(a) propeller torque and slipstream effect;

(b) gyroscopic effect;

(c) asymmetric blade effect.

2.7.3 Describe the term ‘ground effect’ and its effect on aeroplane performance.

2.8 Stalling, spinning and spiral dives

2.8.1 Describe the following:

(a) symptoms of approaching stall;

(b) characteristics of a stall in the following circumstances:

(i) straight and level;

(ii) turning;

(iii) climbing and descending turns.

2.8.2 Explain the following:

(a) the effect of using ailerons when approaching and during the stall;

(b) why an aeroplane may stall at different speeds.

2.8.3 List the effect (increase/decrease/nil) of the following variables on the level flight stall IAS:

(a) power;

(b) flap;

(c) wind shear vertical gusts;

(d) manoeuvres;

(e) weight;

(f) frost and ice;

(g) altitude.

2.8.4 Describe the aerodynamic principles of stall recovery.

2.8.5 Describe manoeuvres during which an aeroplane may stall at an angle which appears to be different to the true stalling angle.

2.8.6 Differentiate between a wing-drop at the stall, spin and spiral dive in a light aeroplane and describe the standard recovery technique from each.

Unit 1.3.3 CADH: CPL aerodynamics – helicopter

1. Reserved

2. Aerodynamics

2.1 Rotorblade aerodynamics

2.1.1 Explain the aerodynamic properties of a rotor blade in respect to the following:

(a) aerofoil shape;

(b) blade twist;

(c) blade taper.

2.1.2 Explain the following terms:

(a) rotor thrust;

(b) rotor drag;

(c) total reaction;

(d) relative airflow;

(e) rotational airflow;

(f) induced airflow;

(g) centrifugal reaction;

(h) rotor disc;

(i) coning angle.

2.2 Hovering flight

2.2.1 Describe the vectors acting on a rotor blade in hovering flight.

2.2.2 Define each of the following items:

(a) ground effect;

(b) tail rotor drift;

(c) rotor shaft tilt effect;

(d) recirculation.

2.2.3 Explain the meaning the following, including the conditions leading thereto and appropriate recovery action:

(a) vortex ring state (settling with power);

(b) loss of tail rotor effectiveness (LTE).

2.3 Rotor blade freedom of movement

2.3.1 Describe the following terms:

(a) feathering;

(b) flapping;

(c) flapping to equality;

(d) dragging;

(e) advance angle;

(f) phase lag.

2.4 Forward flight

2.4.1 Explain the meaning of each of the following terms:

(a) dissymmetry of lift;

(b) flapback;

(c) cyclic limits;

(d) airflow reversal;

(e) retreating blade stall;

(f) compressibility;

(g) inflow roll;

(h) translational lift.

2.4.2 Describe the vectors acting on various sections of a rotor blade in forward flight.

2.5 Power requirements

2.5.1 Select from a list the statement which best describes:

(a) overpitching;

(b) the conditions leading thereto;

(c) the appropriate recovery action.

2.6 Autorotative flight

2.6.1 Explain the meaning of each of the following terms:

(a) autorotative force;

(b) autorotative section.

2.6.2 Describe the effect on autorotative flight of variations in:

(a) all-up-weight;

(b) density altitude;

(c) airspeed;

(d) rotor RPM.

2.6.3 Describe the vectors acting on a rotor blade section during forward autorotative flight.

2.6.4 Explain the vectors acting on a rotor blade section during an autorotative flare.

2.7 Other conditions

2.7.1 Explain the following phenomena and the conditions that can lead to them arising and the appropriate recovery actions to be taken when they arise:

(a) ground resonance;

(b) mast bumping;

(c) dynamic roll-over.

Unit 1.3.4 CADG: CPL aerodynamics – gyroplane – *Reserved*

Unit 1.3.5 CADP: CPL aerodynamics – powered-lift – *Reserved*

Unit 1.3.6 CADS: CPL aerodynamics – airship – *Reserved*