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Fundamentals of Flight

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Fundamentals of Flight

Contents

	Page
PREFACE	xiv
Chapter 1 THEORY OF FLIGHT.....	1-1
Section I – Physical Laws and Principles of Airflow	1-1
Newton’s Laws of Motion	1-1
Fluid Flow	1-2
Vectors and Scalars	1-3
Section II – Flight Mechanics	1-6
Airfoil Characteristics.....	1-6
Airflow and Reactions in the Rotor System.....	1-8
Rotor Blade Angles.....	1-11
Rotor Blade Actions.....	1-12
Helicopter Design and Control	1-17
Section III – In-Flight Forces	1-27
Total Aerodynamic Force	1-27
Lift and Lift Equation	1-28
Drag	1-29
Centrifugal Force and Coning	1-30
Torque Reaction and Antitorque Rotor (Tail Rotor)	1-32
Balance of Forces.....	1-33
Section IV – Hovering.....	1-35
Airflow in Hovering Flight.....	1-35
Ground Effect	1-35
Translating Tendency.....	1-38
Section V – Rotor in Translation.....	1-39
Airflow in Forward Flight.....	1-39
Translational Lift	1-44
Transverse Flow Effect.....	1-45
Effective Translational Lift	1-45
Autorotation	1-46

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	Section VI – Maneuvering Flight.....	1-55
	Aerodynamics	1-55
	Guidelines	1-61
	Section VII – Performance.....	1-61
	Factors Affecting Performance	1-61
	Section VIII – Emergencies	1-65
	Settling with Power	1-65
	Dynamic Rollover	1-68
	Retreating Blade Stall	1-71
	Ground Resonance.....	1-73
	Compressibility Effects.....	1-74
Chapter 2	WEIGHT, BALANCE, AND LOADS	2-1
	Section I – Weight	2-1
	Weight Definitions	2-1
	Weight Versus Aircraft Performance	2-2
	Section II - Balance	2-2
	Center of Gravity	2-2
	Lateral Balance	2-3
	Balance Definitions	2-3
	Principle of Moments	2-5
	Section III – Weight and Balance Calculations	2-5
	Center of Gravity Computation	2-6
	Section IV – Loads	2-8
	Planning	2-8
	Internal Loads	2-10
	External Loads	2-22
	Hazardous Materials	2-25
Chapter 3	ROTARY-WING ENVIRONMENTAL FLIGHT	3-1
	Section I – Cold Weather Operations.....	3-1
	Environmental Factors	3-1
	Flying Techniques	3-6
	Taxiing and Takeoff	3-6
	Maintenance.....	3-10
	Training	3-12
	Section II – Desert Operations.....	3-13
	Environmental Factors	3-13
	Flying Techniques.....	3-17
	Maintenance.....	3-19
	Training	3-21
	Section III – Jungle Operations	3-22
	Environmental Factors	3-22
	Flying Techniques.....	3-24
	Maintenance.....	3-24
	Training	3-25

	Section IV – Mountain Operations	3-26
	Environmental Factors	3-26
	Flying Techniques	3-34
	Maintenance	3-47
	Training.....	3-47
	Section V – Overwater Operations	3-48
	Environmental Factors	3-48
	Flying Techniques	3-49
	Maintenance	3-49
	Training.....	3-49
Chapter 4	ROTARY-WING NIGHT FLIGHT	4-1
	Section I – Night Vision.....	4-1
	Night Vision Capability.....	4-1
	Combat Visual Impairments	4-1
	Aircraft Design	4-2
	Section II – Hemispheric Illumination and Meteorological Conditions.....	4-3
	Light Sources.....	4-3
	Other Considerations	4-4
	Section III – Terrain Interpretation	4-5
	Visual Recognition Cues	4-5
	Factors.....	4-9
	Other Considerations	4-12
	Section IV – Night Vision Sensors	4-13
	Electromagnetic Spectrum	4-14
	Night Vision Devices.....	4-16
	Thermal-Imaging Systems	4-21
	Operational Considerations.....	4-22
	Section V – Night Operations.....	4-28
	Permission Planning.....	4-28
	Night Flight Techniques.....	4-30
	Emergency and Safety Procedures.....	4-37
Chapter 5	ROTARY-WING TERRAIN FLIGHT	5-1
	Section I – Terrain Flight Operations	5-1
	Mission Planning and Preparation.....	5-1
	Aviation Mission Planning System	5-2
	Terrain Flight Limitations	5-2
	Terrain Flight Modes.....	5-2
	Selection of Terrain Flight Modes.....	5-4
	Pickup Zone/Landing Zone Selection	5-4
	Route-Planning Considerations.....	5-6
	Map Selection and Preparation.....	5-9
	Charts, Photographs, and Objective Cards.....	5-11
	Route Planning Card Preparation	5-12
	Hazards to Terrain Flight.....	5-14
	Terrain Flight Performance.....	5-16

	Section II - Training.....	5-17
	Command Responsibility	5-18
	Identification of Unit/Individual Needs.....	5-18
	Training Considerations	5-18
	Training Safety	5-18
Chapter 6	MULTI-AIRCRAFT OPERATIONS	6-1
	Section I – Formation Flight.....	6-1
	Formation Discipline	6-1
	Crew Coordination	6-1
	Crew Responsibilities.....	6-1
	Considerations	6-3
	Formation Breakup	6-9
	Rendezvous and Join-Up Procedures.....	6-13
	Lost Visual Contact Procedures	6-13
	Communication During Formation Flight	6-14
	Section II – Formation Types	6-14
	Two-Helicopter Team.....	6-15
	Fixed Formations	6-15
	Maneuvering Formations	6-19
	Section III – Basic Combat Maneuvers	6-23
	Maneuvering Flight Communications	6-24
	Basic Combat Maneuvers.....	6-24
	Section IV – Planning Considerations and Responsibilities.....	6-30
	Planning Considerations	6-30
	Planning Responsibilities	6-31
	Section V – Wake Turbulence.....	6-32
	In-Flight Hazard	6-32
	Ground Hazard	6-32
	Vortex Generation.....	6-32
	Induced Roll and Counter Control	6-33
	Operational Problem Areas.....	6-34
	Vortex Avoidance Techniques	6-34
Chapter 7	FIXED-WING AERODYNAMICS AND PERFORMANCE	7-1
	Section I – Fixed-Wing Stability.....	7-1
	Motion Sign Principles	7-1
	Static Stability.....	7-2
	Dynamic Stability.....	7-3
	Pitch Stability.....	7-4
	Lateral Stability.....	7-12
	Cross-Effects and Stability.....	7-14
	Section II – High-Lift Devices.....	7-17
	Purpose.....	7-17
	Increasing the Coefficient of Lift.....	7-18
	Types of High-Lift Devices	7-21

	Section III – Stalls	7-24
	Aerodynamic Stall.....	7-25
	Stall Warning and Stall Warning Devices.....	7-27
	Stall Recovery	7-29
	Spins.....	7-29
	Section IV – Maneuvering Flight.....	7-31
	Climbing Flight.....	7-31
	Angle of Climb	7-33
	Rate of Climb.....	7-35
	Aircraft Performance in a Climb or Dive.....	7-35
	Turns.....	7-37
	Slow Flight	7-39
	Descents.....	7-42
	Section V – Takeoff and Landing Performance.....	7-44
	Procedures and Techniques	7-44
	Takeoff.....	7-44
	Section VI – Flight Control	7-49
	Development	7-49
	Control Surface and Operation Theory	7-49
	Longitudinal Control.....	7-51
	Directional Control.....	7-53
	Lateral Control.....	7-54
	Control Forces	7-54
	Control Systems	7-57
	Propellers	7-59
	Section VII – Multiengine Operations.....	7-61
	Twin-Engine Aircraft Performance	7-61
	Asymmetric Thrust.....	7-62
	Critical Engine	7-62
	Minimum Single-Engine Control Speed	7-63
	Single-Engine Climbs	7-65
	Single-Engine Level Flight.....	7-67
	Single-Engine Descents.....	7-68
	Single-Engine Approach and Landing.....	7-68
	Propeller Feathering.....	7-68
	Accelerate-Stop Distance.....	7-69
	Accelerate-Go Distance	7-70
Chapter 8	FIXED-WING ENVIRONMENTAL FLIGHT	8-1
	Section I – Cold Weather/Icing Operations.....	8-1
	Environmental Factors	8-1
	Aircraft Equipment.....	8-7
	Flying Techniques	8-10
	Training.....	8-15
	Section II – Mountain Operations	8-16
	Environmental Factors	8-16
	Flying Techniques	8-17

	Section III – Overwater Operations	8-17
	Oceanographic Terminology.....	8-17
	Ditching	8-18
	Section IV – Thunderstorm Operations	8-22
	Environmental Factors	8-23
	Flying Techniques.....	8-24
	Training	8-26
Chapter 9	FIXED-WING NIGHT FLIGHT	9-1
	Section I – Preparation and Preflight.....	9-1
	Equipment.....	9-1
	Lighting.....	9-1
	Parking Ramp Check.....	9-2
	Preflight.....	9-2
	Section II – Taxi, Takeoff, and Departure Climb	9-3
	Taxi	9-3
	Takeoff and Climb.....	9-3
	Section III – Orientation and Navigation	9-4
	Visibility	9-4
	Maneuvers	9-5
	Disorientation and Reorientation	9-5
	Cross-Country Flights	9-5
	Overwater Flights.....	9-5
	Illusions	9-5
	Section IV – Approaches and Landings	9-5
	Distance	9-5
	Airspeed.....	9-5
	Depth Perception	9-6
	Approaching Airports	9-6
	Entering Traffic.....	9-6
	Final Approach.....	9-6
	Executing Roundout.....	9-7
	Section V – Night Emergencies	9-9
	GLOSSARY	Glossary-1
	REFERENCES.....	References-1
	INDEX	Index-1

Figures

Figure 1-1. Water flow through a tube.....	1-2
Figure 1-2. Venturi effect.....	1-2
Figure 1-3. Venturi flow	1-3
Figure 1-4. Resultant by parallelogram method	1-4
Figure 1-5. Resultant by the polygon method	1-5
Figure 1-6. Resultant by the triangulation method	1-5
Figure 1-7. Force vectors on an airfoil segment.....	1-6
Figure 1-8. Force vectors on aircraft in flight.....	1-6
Figure 1-9. Symmetrical airfoil section	1-8
Figure 1-10. Nonsymmetrical (cambered) airfoil section	1-8
Figure 1-11. Relative wind.....	1-9
Figure 1-12. Rotational relative wind.....	1-9
Figure 1-13. Induced flow (downwash)	1-10
Figure 1-14. Resultant relative wind.....	1-10
Figure 1-15. Angle of incidence and angle of attack	1-11
Figure 1-16. Blade rotation and blade speed	1-12
Figure 1-17. Feathering	1-13
Figure 1-18. Flapping in directional flight	1-14
Figure 1-19. Flapping (advancing blade 3 o'clock position).....	1-14
Figure 1-20. Flapping (retreating blade 9-o'clock position).....	1-14
Figure 1-21. Flapping (blade over the aircraft nose).....	1-15
Figure 1-22. Flapping (blade over the aircraft tail)	1-15
Figure 1-23. Lead and lag	1-16
Figure 1-24. Under slung design of semirigid rotor system	1-17
Figure 1-25. Gyroscopic precession	1-18
Figure 1-26. Rotor head control systems	1-19
Figure 1-27. Stationary and rotating swashplates tilted by cyclic control	1-19
Figure 1-28. Stationary and rotating swashplates tilted in relation to mast	1-20
Figure 1-29. Pitch-change arm rate of movement over 90 degrees of travel	1-21
Figure 1-30. Rotor flapping in response to cyclic input	1-21
Figure 1-31. Cyclic feathering	1-22
Figure 1-32. Input servo and pitch-change horn offset	1-23
Figure 1-33. Cyclic pitch variation—full forward, low pitch	1-24
Figure 1-34. Fully articulated rotor system.....	1-25
Figure 1-35. Semirigid rotor system	1-25
Figure 1-36. Effect of tail-low attitude on lateral hover attitude	1-26
Figure 1-37. Cyclic control response around the lateral and longitudinal axes	1-27
Figure 1-38. Total aerodynamic force	1-28
Figure 1-39. Forces acting on an airfoil.....	1-28
Figure 1-40. Drag and airspeed relationship.....	1-30
Figure 1-41. Effects of centrifugal force and lift.....	1-31

Figure 1-42. Decreased disk area (loss of lift caused by coning).....	1-31
Figure 1-43. Torque reaction	1-32
Figure 1-44. Balanced forces; hovering with no wind.....	1-33
Figure 1-45. Unbalanced forces causing acceleration	1-34
Figure 1-46. Balanced forces; steady-state flight	1-34
Figure 1-47. Unbalanced forces causing deceleration	1-35
Figure 1-48. Airflow in hovering flight	1-35
Figure 1-49. In ground effect hover	1-37
Figure 1-50. Out of ground effect hover.....	1-38
Figure 1-51. Translating tendency	1-39
Figure 1-52. Differential velocities on the rotor system caused by forward airspeed....	1-40
Figure 1-53. Blade areas in forward flight.....	1-41
Figure 1-54. Flapping (advancing blade, 3-o'clock position)	1-42
Figure 1-55. Flapping (retreating blade, 9-o'clock position)	1-42
Figure 1-56. Blade pitch angles	1-43
Figure 1-57. Translational lift (1 to 5 knots)	1-44
Figure 1-58. Translational lift (10 to 15 knots)	1-44
Figure 1-59. Transverse flow effect	1-45
Figure 1-60. Effective translational lift.....	1-46
Figure 1-61. Blade regions in vertical autorotation descent	1-47
Figure 1-62. Force vectors in vertical autorotative descent.....	1-49
Figure 1-63. Autorotative regions in forward flight.....	1-50
Figure 1-64. Force vectors in level-powered flight at high speed.....	1-51
Figure 1-65. Force vectors after power loss—reduced collective	1-51
Figure 1-66. Force vectors in autorotative steady-state descent	1-52
Figure 1-67. Autorotative deceleration.....	1-52
Figure 1-68. Drag and airspeed relationship	1-54
Figure 1-69. Counterclockwise blade rotation	1-56
Figure 1-70. Lift to weight	1-59
Figure 1-71. Aft cyclic results.....	1-60
Figure 1-72. Density altitude computation	1-64
Figure 1-73. Induced flow velocity during hovering flight.....	1-66
Figure 1-74. Induced flow velocity before vortex ring state	1-66
Figure 1-75. Vortex ring state	1-67
Figure 1-76. Settling with power region	1-68
Figure 1-77. Downslope rolling motion	1-70
Figure 1-78. Upslope rolling motion.....	1-70
Figure 1-79. Retreating blade stall (normal hovering lift pattern)	1-72
Figure 1-80. Retreating blade stall (normal cruise lift pattern).....	1-72
Figure 1-81. Retreating blade stall (lift pattern at critical airspeed—retreating blade stall)	1-73
Figure 1-82. Ground resonance.....	1-74
Figure 1-83. Compressible and incompressible flow comparison	1-76
Figure 1-84. Normal shock wave formation	1-77

Figure 2-1. Helicopter station diagram	2-4
Figure 2-2. Aircraft balance point	2-5
Figure 2-3. Locating aircraft center of gravity	2-6
Figure 2-4. Fuel moments	2-7
Figure 2-5. Center of gravity limits chart	2-8
Figure 2-6. Weight-spreading effect of shoring	2-11
Figure 2-7. Load contact pressure	2-12
Figure 2-8. Formulas for load pressure calculations	2-13
Figure 2-9. Determining general cargo center of gravity	2-14
Figure 2-10. Determining center of gravity of wheeled vehicle	2-15
Figure 2-11. Compartment method steps	2-16
Figure 2-12. Station method steps	2-17
Figure 2-13. Effectiveness of tie-down devices	2-19
Figure 2-14. Calculating tie-down requirements	2-21
Figure 3-1. Weather conditions conducive to icing	3-3
Figure 3-2. Ambient light conditions	3-5
Figure 3-3. Depth perception	3-9
Figure 3-4. Desert areas of the world	3-14
Figure 3-5. Sandy desert terrain	3-15
Figure 3-6. Rocky plateau desert terrain	3-16
Figure 3-7. Mountain desert terrain	3-16
Figure 3-8. Jungle areas of the world	3-22
Figure 3-9. Types of wind	3-27
Figure 3-10. Light wind	3-28
Figure 3-11. Moderate wind	3-28
Figure 3-12. Strong wind	3-29
Figure 3-13. Mountain (standing) wave	3-29
Figure 3-14. Cloud formations associated with mountain wave	3-30
Figure 3-15. Rotor streaming turbulence	3-31
Figure 3-16. Wind across a ridge	3-32
Figure 3-17. Snake ridge	3-32
Figure 3-18. Wind across a crown	3-33
Figure 3-19. Shoulder wind	3-33
Figure 3-20. Wind across a canyon	3-34
Figure 3-21. Mountain takeoff	3-35
Figure 3-22. High reconnaissance flight patterns	3-38
Figure 3-23. Computing wind direction between two points	3-39
Figure 3-24. Computing wind direction using the circle maneuver	3-39
Figure 3-25. Approach paths and areas to avoid	3-40
Figure 3-26. Nap-of-the-earth or contour takeoff (terrain flight)	3-43
Figure 3-27. Ridge crossing at a 45-degree angle (terrain flight)	3-44
Figure 3-28. Steep turns or climbs at terrain flight altitudes	3-44
Figure 3-29. Flight along a valley (terrain flight)	3-45
Figure 3-30. Nap-of-the-earth or contour approach (terrain flight)	3-46

Figure 4-1. Identification by object size	4-6
Figure 4-2. Identification by object shape	4-7
Figure 4-3. Identification by object contrast	4-8
Figure 4-4. Identification by object viewing distance	4-9
Figure 4-5. Electromagnetic Spectrum	4-14
Figure 4-6. IR energy	4-15
Figure 4-7. Image intensifier	4-16
Figure 4-8. AN/AVS-6 in operational position	4-17
Figure 4-9. Pilotage system	4-21
Figure 4-10. Target acquisition system.....	4-22
Figure 4-11. Atmospheric effects on IR radiation	4-24
Figure 4-12. Infrared energy crossover	4-25
Figure 4-13. Parallax effect.....	4-26
Figure 4-14. Night visual meteorological conditions takeoff	4-32
Figure 4-15. Approach to a lighted inverted Y	4-34
Figure 4-16. Approach to a lighted T	4-36
Figure 5-1. Modes of flight	5-3
Figure 5-2. Route planning map symbols	5-10
Figure 5-3. Sample–joint operations graphic map preparation	5-11
Figure 5-4. Example of an en route card	5-13
Figure 5-5. Example of an objective card	5-14
Figure 6-1. Horizontal distance	6-5
Figure 6-2. Stepped-up vertical separation.....	6-6
Figure 6-3. Echelon formation before breakup	6-9
Figure 6-4. Left break with 10-second interval for landing.....	6-10
Figure 6-5. Breakup into two elements	6-11
Figure 6-6. Formation breakup–inadvertent instrument meteorological conditions	6-12
Figure 6-7. Two-helicopter section/element.....	6-15
Figure 6-8. Staggered right and left formation	6-16
Figure 6-9. Echelon right and left formation.....	6-17
Figure 6-10. Trail formation.....	6-18
Figure 6-11. V-formation	6-19
Figure 6-12. Team combat cruise.....	6-20
Figure 6-13. Flight combat cruise	6-20
Figure 6-14. Combat cruise right	6-21
Figure 6-15. Combat cruise left.....	6-22
Figure 6-16. Combat trail	6-23
Figure 6-17. Combat spread	6-23
Figure 6-18. Basic combat maneuver circle	6-24
Figure 6-19. Tactical turn away.....	6-25
Figure 6-20. Tactical turn to.....	6-26
Figure 6-21. Dig and pinch maneuvers.....	6-26
Figure 6-22. Split turn maneuver	6-27
Figure 6-23. In-place turn.....	6-27

Figure 6-24. Cross turn in or out	6-28
Figure 6-25. Cross turn cover (high/low).....	6-28
Figure 6-26. Break turn left/right.....	6-29
Figure 6-27. Break turn left/right (high/low).....	6-29
Figure 6-28. Shackle turn	6-30
Figure 6-29. Wake vortex generation	6-33
Figure 7-1. Stability nomenclature.....	7-1
Figure 7-2. Nonoscillatory motion.....	7-2
Figure 7-3. Oscillatory motion	7-4
Figure 7-4. C_M versus C_L	7-5
Figure 7-5. Fixed-wing aircraft center of gravity and aerodynamic center.....	7-6
Figure 7-6. Wing contribution to longitudinal stability.....	7-6
Figure 7-7. Negative pitching moment about the aerodynamic center of a positive-cambered airfoil	7-7
Figure 7-8. Positive longitudinal stability of a positive-cambered airfoil.....	7-7
Figure 7-9. Negative longitudinal stability of a positive-cambered airfoil	7-8
Figure 7-10. Lift as a stabilizing moment to the horizontal stabilizer	7-9
Figure 7-11. Thrust axis about center of gravity.....	7-9
Figure 7-12. Positive sideslip angle.....	7-10
Figure 7-13. Directional stability (β versus C_N)	7-11
Figure 7-14. Dorsal fin decreases drag.....	7-11
Figure 7-15. Fixed-wing aircraft configuration positive yawing moment	7-12
Figure 7-16. Horizontal lift component produces sideslip	7-13
Figure 7-17. Positive static lateral stability	7-13
Figure 7-18. Dihedral angle.....	7-13
Figure 7-19. Dihedral stability.....	7-14
Figure 7-20. Adverse yaw	7-15
Figure 7-21. Slipstream and yaw.....	7-17
Figure 7-22. Asymmetric loading (propeller-factor).....	7-17
Figure 7-23. Increasing camber with trailing-edge flap	7-19
Figure 7-24. Suction boundary-layer control	7-20
Figure 7-25. Blowing boundary-layer control	7-20
Figure 7-26. Vortex generators	7-21
Figure 7-27. Angle of incidence change with flap deflection.....	7-22
Figure 7-28. Types of high-lift devices	7-23
Figure 7-29. C_L max increase with slotted flap.....	7-24
Figure 7-30. Coefficient of lift curve.....	7-25
Figure 7-31. Various airfoil angles of attack.....	7-26
Figure 7-32. Boundary-layer separation.....	7-26
Figure 7-33. C_L curves for cambered and symmetrical airfoils	7-28
Figure 7-34. Stall strip	7-28
Figure 7-35. Flapper switch.....	7-29
Figure 7-36. Spins	7-30
Figure 7-37. Climb angle and rate.....	7-32

Figure 7-38. Force-vector diagram for climbing flight.....	7-33
Figure 7-39. Wind effect on maximum climb angle.....	7-34
Figure 7-40. Full-power polar diagram.....	7-36
Figure 7-41. Polar curve	7-37
Figure 7-42. Effect of turning flight.....	7-38
Figure 7-43. Effect of load factor on stalling speed	7-40
Figure 7-44. Best glide speed	7-44
Figure 7-45. Net accelerating force	7-45
Figure 7-46. Landing roll velocity.....	7-48
Figure 7-47. Using flaps to increase camber.....	7-50
Figure 7-48. Operation of aileron in a turn.....	7-50
Figure 7-49. Effect of elevator and rudder on moments	7-51
Figure 7-50. Effect of center of gravity location on longitudinal control.....	7-52
Figure 7-51. Adverse moments during takeoff.....	7-53
Figure 7-52. Hinge moment	7-54
Figure 7-53. Aerodynamic balancing using horns	7-55
Figure 7-54. Aerodynamic balancing using a balance board	7-56
Figure 7-55. Aerodynamic balancing using a servo tab	7-56
Figure 7-56. Spoiler used as control surface.....	7-58
Figure 7-57. Wing flap control.....	7-58
Figure 7-58. Blade angle affected by revolutions per minute	7-60
Figure 7-59. Forces created during single-engine operation.....	7-63
Figure 7-60. Sideslip	7-65
Figure 7-61. One-engine inoperative flight path	7-66
Figure 7-62. Windmilling propeller creating drag.....	7-68
Figure 7-63. Required takeoff runway lengths.....	7-70
Figure 7-64. Balanced field length	7-71
Figure 8-1. Lift curve	8-3
Figure 8-2. Drag curve	8-4
Figure 8-3. Tail stall pitchover.....	8-6
Figure 8-4. Pneumatic boots.....	8-9
Figure 8-5. Propeller ice control.....	8-10
Figure 8-6. Wind swell ditch heading.....	8-19
Figure 8-7. Single swell.....	8-19
Figure 8-8. Double swell (15 knot wind)	8-20
Figure 8-9. Double swell (30 knot wind)	8-20
Figure 8-10. Swell (50 knot wind)	8-21
Figure 8-11. Effect of microburst.....	8-24
Figure 9-1. Positive climb.....	9-4
Figure 9-2. Typical light pattern for airport identification.....	9-6
Figure 9-3. Visual approach slope indicator	9-7
Figure 9-4. Roundout (when tire marks are visible).....	9-8

Tables

Table 1-1. Airfoil terminology.....	1-7
Table 1-2. Aircraft reaction to forces	1-18
Table 1-3. Bank angle versus torque	1-59
Table 1-4. Speed of sound variation with temperature and altitude.....	1-75
Table 2-1. Responsibilities	2-9
Table 2-2. Internal loading considerations	2-10
Table 2-3. Percentage restraint chart.....	2-20
Table 4-1. Position distance	4-2
Table 5-1. Mission, enemy, terrain and weather, troops and support available, time available, civil considerations and terrain flight modes.....	5-4
Table 5-2. Pickup zone selection considerations	5-5
Table 5-3. Pickup zone selection considerations.....	5-5
Table 5-4. Route planning considerations.....	5-7
Table 5-5. Example of a navigation card.....	5-12
Table 6-1. Sample lighting conditions	6-7
Table 8-1. Temperature ranges for ice formation.....	8-2
Table 8-2. Oceanographic terminology	8-17

Preface

Field manual (FM) 3-04.203 still presents information to plan and conduct common aviation tasks for fixed- and rotary-wing flight. However, it has become more inclusive and its scope broadened to reduce the number of manuals used by Army crewmembers for reference

One of the underlying premises of Army aviation is if crewmembers understand ‘why’ they will be better prepared to ‘do’ when confronted with the unexpected. FM 3-04.203 endeavors to ensure that crewmembers understand the basic physics of flight, and the dynamics associated with fixed- and rotary-wing aircraft. A comprehensive understanding of these principles will better prepare a crewmember for flight, transition training, and tactical flight operations.

Because the U.S. Army prepares its Soldiers to operate anywhere in the world, this publication describes the unique requirements and flying techniques crewmembers will use to successfully operate in extreme environments, not always encountered in home station training.

As a full-time force, the U.S. Army is capable of using the advantages of its superior night operation technologies to leverage combat power. To that end, Army crewmembers must be familiar and capable of performing their mission proficiently and tactically at night. The information on night vision systems (NVSs) and night operations in this circular will provide the basis for acquiring these skills.

Every aviator understands that the primary purpose is to operate aircraft safely. Every crewmember must perform the mission effectively and decisively in tactical and combat operations. FM 3-04.203 also covers basic tactical flight profiles, formation flight, and air combat maneuvers.

FM 3-04.203 is an excellent reference for Army crewmembers; however, it can not be expected that this circular is all inclusive or a full comprehension of the information will be obtained by simply reading the text. A firm understanding will begin to occur as crewmembers become more experienced in their particular aircraft, study the tactics, techniques, and procedures (TTP) of their units, and study other sources of information. Crewmembers honing skills should review FM 3-04.203 periodically to gain new insights.

This publication applies to the Active Army, the Army National Guard/Army National Guard of the United States, and the United States Army Reserve unless otherwise stated.

The proponent of this publication is Headquarters, United States Army Training and Doctrine Command (TRADOC). Send comments and recommendations on Department of the Army (DA) Form 2028 (Recommended Changes to publications and Blank Forms) or automated link (<http://www.usapa.army.mil/da2028/daform2028.asp>) to Commander, U.S. Army Aviation Warfighting Center ATTN: ATZQ-TD-D, Fort Rucker, Alabama 36362-5263. Comments may be e-mailed to the Directorate of Training and Doctrine at av.doctrine@us.army.mil. Other doctrinal information can be found on the Internet at Army Knowledge Online (AKO) or call defense switch network (DSN) 558-3551 or (334) 255-3551.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

This publication has been reviewed for operations security considerations.

Chapter 1

Theory of Flight

This chapter presents aerodynamic fundamentals and principles of rotary-wing flight. The content relates to flight operations and performance of normal mission flight tasks. It covers theory and application of aerodynamics for the aviator, whether in flight training or general flight operations. Chapter 7 presents additional information on fixed-wing (FW) flight.

SECTION I – PHYSICAL LAWS AND PRINCIPLES OF AIRFLOW

NEWTON’S LAWS OF MOTION

1-1. Newton’s three laws of motion are inertia, acceleration, and action/reaction. These laws apply to flight of any aircraft. A working knowledge of the laws and their applications will assist in understanding aerodynamic principles discussed in this chapter. Interaction between the laws of motion and aircraft mechanical actions causes the aircraft to fly and allows aviators to control such flight.

INERTIA

1-2. A body at rest will remain at rest, and a body in motion will remain in motion at the same speed and in the same direction unless acted upon by an external force. Nothing starts or stops without an outside force to bring about or prevent motion. Inertia is a body’s resistance to a change in its state of motion.

Contents	
Section I – Physical Laws and Principles of Airflow	1-1
Section II – Flight Mechanics	1-6
Section III – In-Flight Forces.....	1-27
Section IV – Hovering.....	1-35
Section V – Rotor in Translation	1-39
Section VI – Maneuvering Flight	1-55
Section VII – Performance	1-61
Section VIII – Emergencies.....	1-66

ACCELERATION

1-3. The force required to produce a change in motion of a body is directly proportional to its mass and rate of change in its velocity. Acceleration refers to an increase or decrease—often called deceleration—in velocity. Acceleration is a change in magnitude or direction of the velocity vector with respect to time. Velocity refers to direction and rate of linear motion of an object.

ACTION/REACTION

1-4. For every action, there is an equal and opposite reaction. When an interaction occurs between two bodies, equal forces in opposite directions are imparted to each body.

FLUID FLOW

BERNOULLI'S PRINCIPLE

1-5. This principle describes the relationship between internal fluid pressure and fluid velocity. It is a statement of the law of conservation of energy and helps explain why an airfoil develops an aerodynamic force. The concept of conservation of energy states energy cannot be created or destroyed and the amount of energy entering a system must also exit. A simple tube with a constricted portion near the center of its length illustrates this principle. An example is using water through a garden hose (figure 1-1). The mass of flow per unit area (cross sectional area of tube) is the mass flow rate. In figure 1-1, the flow into the tube is constant, neither accelerating nor decelerating; thus, the mass flow rate through the tube must be the same at stations 1, 2, or 3. If the cross sectional area at any one of these stations—or any given point—in the tube is reduced, the fluid velocity must increase to maintain a constant mass flow rate to move the same amount of fluid through a smaller area. Fluid speeds up in direct proportion to the reduction in area. Venturi effect is the term used to describe this phenomenon. Figure 1-2 illustrates what happens to mass flow rate in the constricted tube as the dimensions of the tube change.

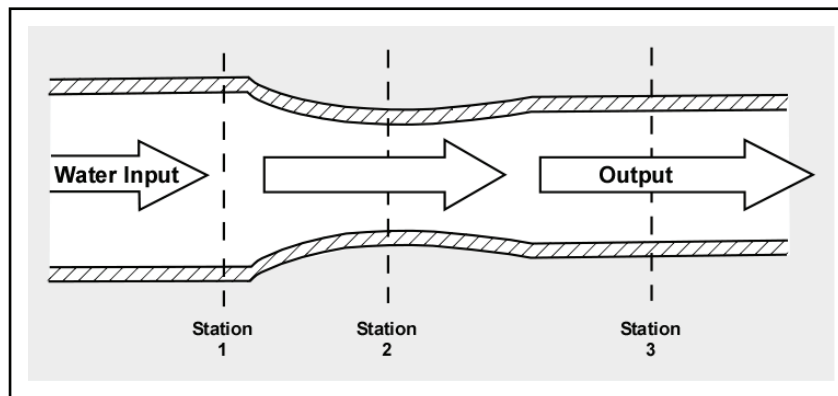


Figure 1-1. Water flow through a tube

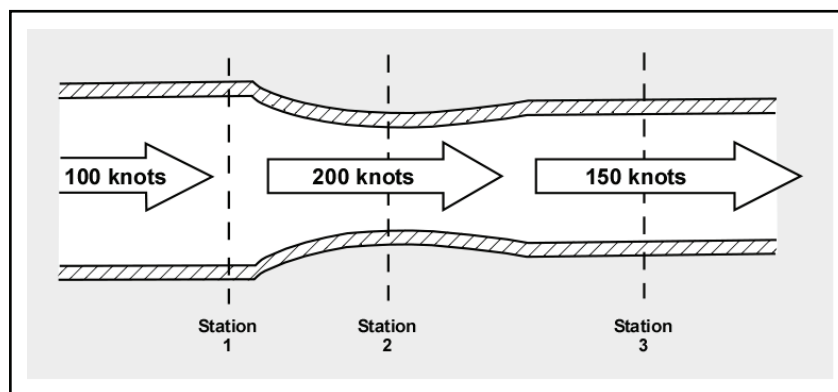


Figure 1-2. Venturi effect

VENTURI FLOW

1-6. While the amount of total energy within a closed system (the tube) does not change, the form of the energy may be altered. Pressure of flowing air may be compared to energy in that the total pressure of