Introduction to Gliders

Exploring Flight without an Engine

Welcome

- Instructor – Paul Jurgens
  - Chief Instructor for Glider, Multiengine, and Primary Courses
  - Master CFI & Master GI
  - pjurgens@sportys.com or 513.735.9100 x212
- Schedule
  - 9 AM to 5 PM, today
  - Break for Lunch – Noonish
  - Other Breaks – Occasionally

Glider Training at Sporty's Academy

Terminology and Those Good 'OI Regulations

Terminology

- Glider
  - (Per FAA) A heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces. Its free flight does not depend principally on an engine.
- Sailplane
  - The FAA does not distinguish between gliders and sailplanes. They use the terms interchangeably in advisory circulars concerning the certification of gliders and powered gliders.
  - In the glider community, sailplanes are typically considered to be gliders with higher performance characteristics.

Terminology

- Gliding vs. Soaring
  - Soaring generally has the connotation of sustained flight without an engine.
  - Gliding may also be used in this sense but often indicates a controlled descent.

Adding Glider Privileges

- No FAA knowledge exam for an add-on rating if rated in airplanes at same level.
- You do need to pass an oral and flight practical exam.
- Add a glider rating to Private certificate
  - 3 hours of glider time assuming that you already have 40 hours of flight time in heavier-than-air aircraft.
  - At least 10 training flights with a glider instructor and 10 solo flights.
  - 3 of the training flights must be within 2 calendar months prior to the practical test.

Adding Glider Privileges

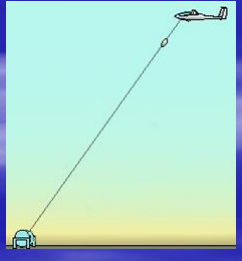
- Add a glider rating to Commercial certificate (with 200 hours of flight time in heavier-than-air aircraft)
  - 3 hours of flight training or 10 training flights in a glider with an instructor.
  - 3 training flights must be within 2 calendar months prior to the practical test.
  - At least 20 PIC flights / 5 of PIC must be solo.
- No medical certificate required for any glider rating.
  - Must be able to self-certify OK for flight.

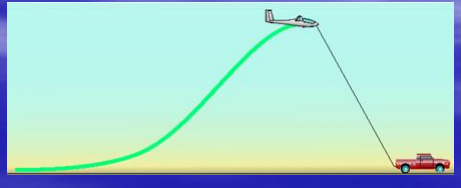
Glider as First Certificate

- 14 years old to solo in a glider.
- 16 to earn a private pilot in a glider.
- Knowledge and practical test required.
- If less than 40 hours of flight time in heavier-than-air aircraft:
  - 10 hours of flight time in a glider.
  - 20 flights in a glider.
  - 3 training flights must be within 2 calendar months prior to the practical test.
  - 2 hours of solo flight time in a glider with at least 10 launches and landings.

Launch Methods

- How can we get a glider into the air?





Self-Launch Glider at ECA

Can an Airplane Pilot Fly the Xtreme with Pax without a Glider Rating?

- NO!!!
- Why not?

1.2 CERTIFICATION BASIS

The HK 36 TC powered sailplane has beer
accordance with Change 5 of JAR-22 for sailpla
HK 36 TS. The Type Certificate Data Sheet N

Category of Airworthiness: Utility.

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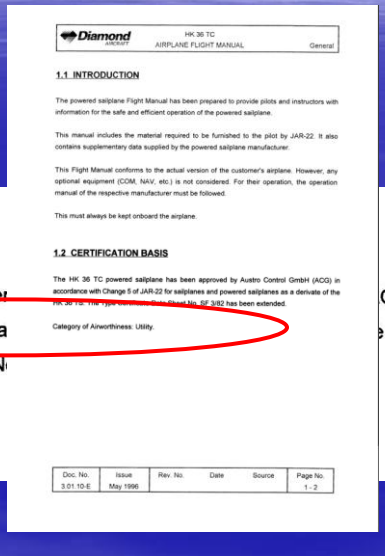

Diamond AIRCRAFT — HK 36 TC — AIRPLANE FLIGHT MANUAL — General

1.1 INTRODUCTION

The powered sailplane Flight Manual has been prepared to provide pilots and instructors with information for the safe and efficient operation of the powered sailplane.

This manual includes the material required to be furnished to the pilot by JAR-22. It also contains supplementary data supplied by the powered sailplane manufacturer.

This Flight Manual conforms to the actual version of the customer's airplane. However, any optional equipment (COM, NAV, etc.) is not considered. For their operation, the operation manual of the respective manufacturer must be followed.

This must always be kept onboard the airplane.

1.2 CERTIFICATION BASIS

The HK 36 TC powered sailplane has been approved by Austro Control GmbH (ACG) in accordance with Change 5 of JAR-22 for sailplanes and powered sailplanes as a derivate of the HK 36 TS. The Type Certificate Data Sheet No. EF 3/82 has been extended.

Category of Airworthiness: Utility.

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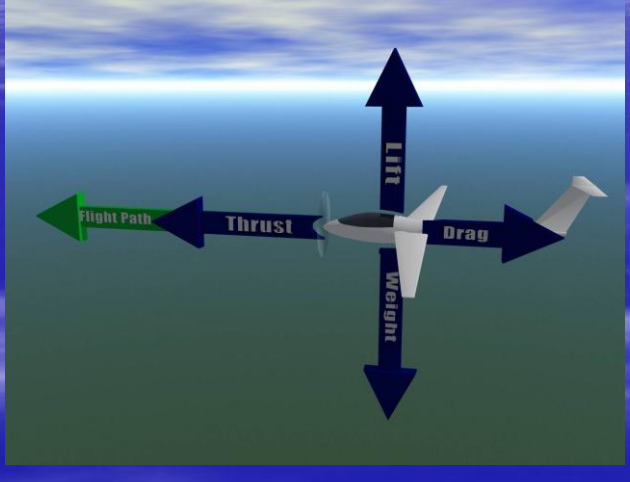
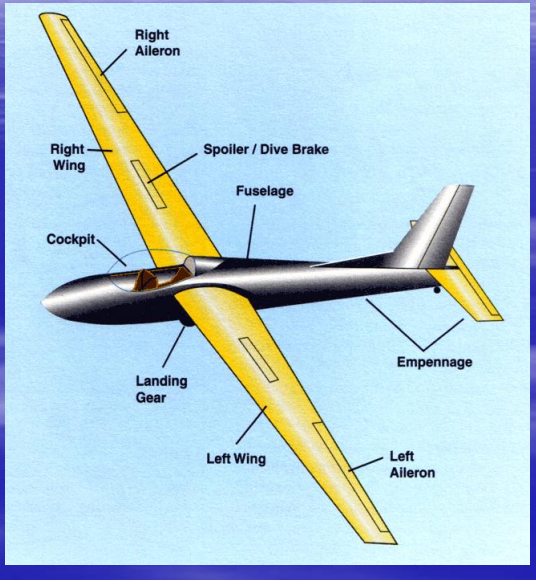
Glider Aerodynamics and Systems

Review of Four Forces

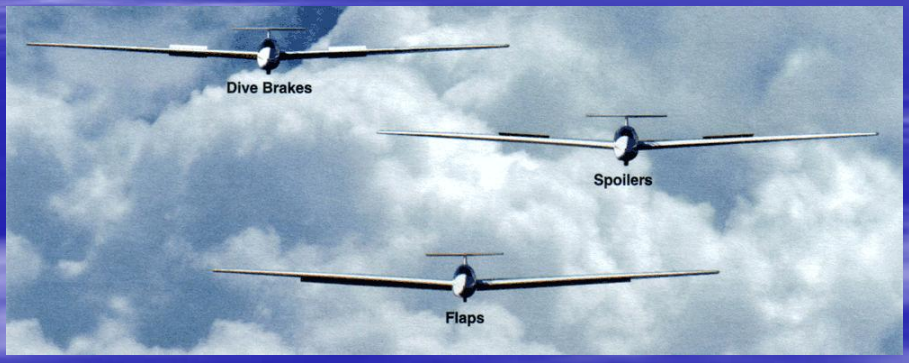


From “So You Want to Fly Gliders”

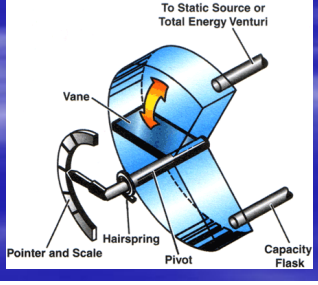
Glider Components

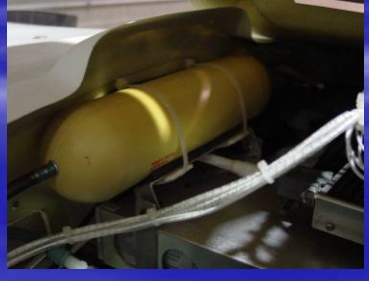


Types of Lift & Drag Devices

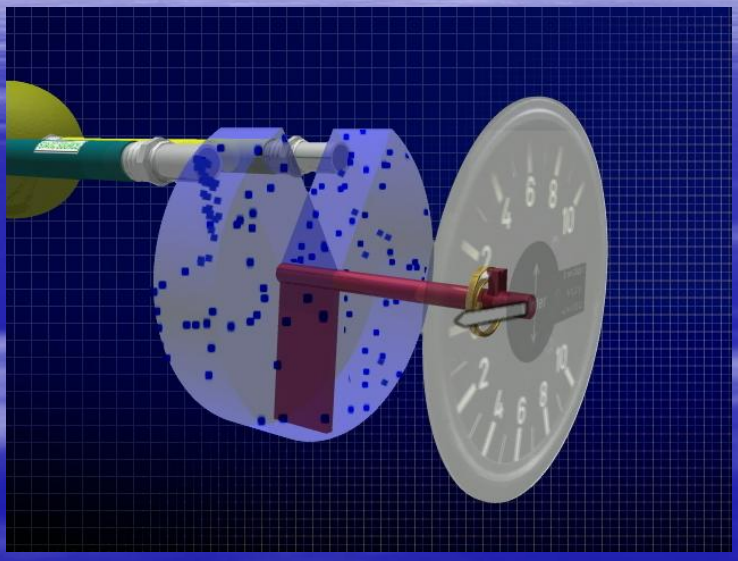


Pitot-Static Instruments





Operation of a Variometer



Variometers

- Mechanical or Electronic.
- May have both visual and audible indications.
- Uncompensated units will measure climbs and descents due to the vertical movement of the airmass as well as those resulting from a dive or a pull-up.
  - Most interested in movement of airmass.
- Total energy compensating system is designed to reduce the indication of “stick thermals.”
  - Senses change in speed and adjusts vario indication.
- “Netto” or airmass variometer indicates the vertical speed of the airmass only.
  - It does not indicate the vertical speed of the glider when descending in still air.
  - This may be accomplished using a controlled leak in the pitot head or electronically.
  - Accurate calibration of a netto system can be difficult.

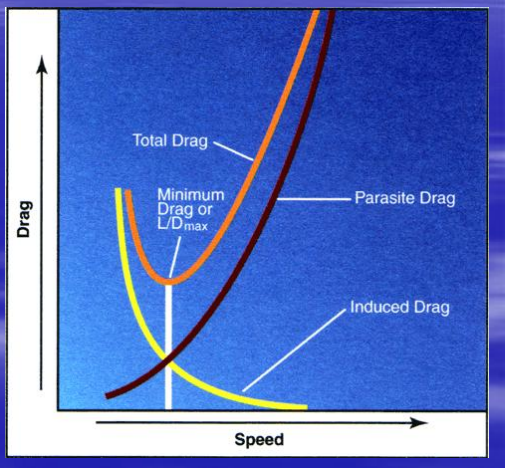
Glider Performance and Speed-To-Fly

Glider Performance

- Many of the same performance considerations as airplanes.
  - Pressure altitude, temperature, humidity, density altitude, weight & balance, etc.
- “Best Glide” gets more complicated than taught in an airplane.
  - More in a moment.
- Glide ratio is a factor of the design, speed, and drag of the aircraft.
  - All other factors being the same, changes in weight do not change the glide ratio for a particular configuration, only the speed at which the ratio is obtained.
    - Heavier = Faster

Simple View of Best Glide Speed

- Best glide speed.
  - Maximum lift over drag speed
  - Best L over D
  - L over D max
  - L / D_{MAX}
  - Minimum Drag
- A bit too simple for gliding flight.



Speed-to-Fly

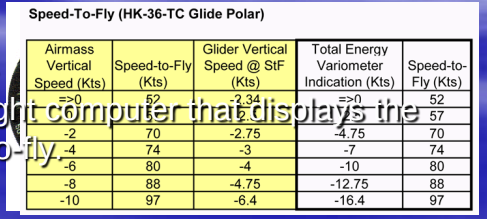
- Traditional Definition
  - The Indicated Airspeed which produces the flattest glide in any situation of convection.
- FAA Definitions
  - Optimum speed through the (sinking or rising) air mass to achieve either the furthest glide or fastest average cross-country speed depending on the objectives during a flight.
  - Speed-to-fly refers to the optimum airspeed for proceeding from one source of lift to another.

Speed-to-Fly

- Per the FAA, speed-to-fly depends on the following.
  - The rate-of-climb the pilot expects to achieve in the next thermal or updraft.
    - This is more related to competition and cross-country soaring. Beginners should use an expectation of 0.
  - The rate of ascent or descent of the air mass through which the glider is flying.
  - The glider's inherent sink rate at all airspeeds between minimum sink airspeed and never exceed airspeed.
  - Headwind or tailwind.
    - Many Glider Pilots would disagree with this one. This is related to Final Glide Speed calculations, not pure Speed-to-Fly. Thermal to thermal is within the airmass; horizontal movement of the airmass is irrelevant.

Speed-to-Fly

- OK, What does this mean?
- In non-convective air, wings level speed-to-fly = traditional best glide.
- In general terms, go faster in sinking air, go slower in rising air.
- How fast or how slow must be calculated.
  - By placing a speed-to-fly ring (MacCready ring) around the variometer dial.
  - By using a table or chart.
  - By using an electronic flight computer that displays the current optimum speed-to-fly.

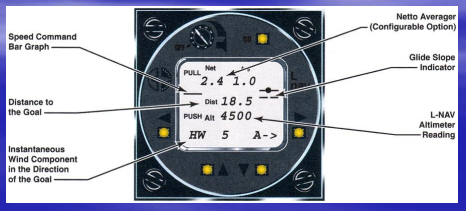


Speed-To-Fly (HK-36-TC Glide Polar)

Airmass Vertical Speed (Kts)	Speed-to-Fly (Kts)	Glider Vertical Speed @ StF (Kts)	Total Energy Variometer Indication (Kts)	Speed-to-Fly (Kts)
=>0	52	-2.34	=>0	52
-1	57	-2.5	-2.5	57
-2	70	-2.75	-4.75	70
-4	74	-3	-7	74
-6	80	-4	-10	80
-8	88	-4.75	-12.75	88
-10	97	-6.4	-16.4	97

Final Glide Speed

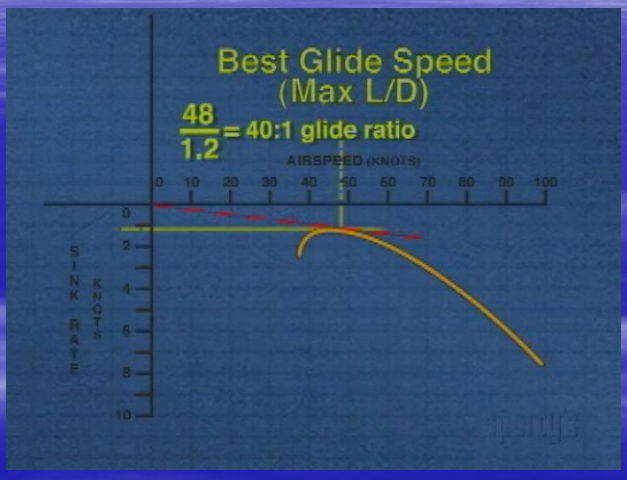
- Speed-to-Fly adjusted for headwind or tailwind.
- Indicated airspeed required when seeking to reach a point on the ground.
- Can be calculated and placed on a chart or determined with a manual or electronic glide computer.
- Rule of thumb for headwinds - Add half or two-thirds of the headwind component to your calm-wind final glide airspeed for a rough final glide speed.



Glider Polars

- Summary of the rate of sink in terms of airspeed as supplied by the manufacturer in a graph called a polar curve, or simply a polar.
  - The vertical axis of the polar shows the sink rate in knots, while the horizontal axis shows airspeed in knots.
  - Need same units on each axis to be most useful.
- Every type of glider has a characteristic polar derived either from theoretical calculations or by actual in-flight measurement of the sink rate at different speeds.
  - The polar of an individual glider may vary slightly depending on condition of the wings, sealing around control surfaces, and the number of bugs on the wing.
- The polar forms the basis for speed-to-fly and final glide calculations.

Glider Polars



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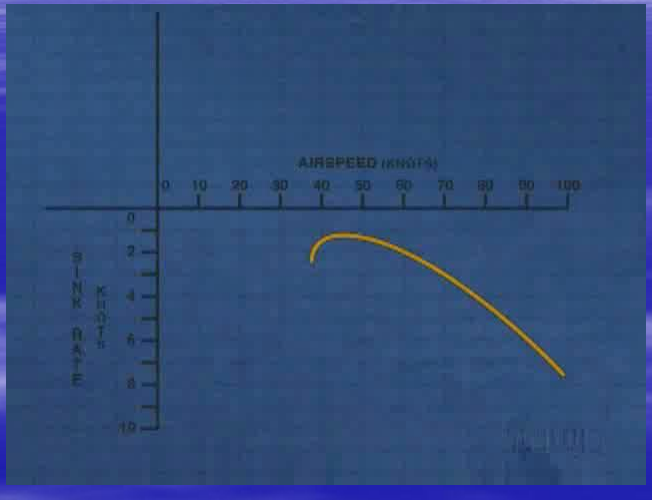
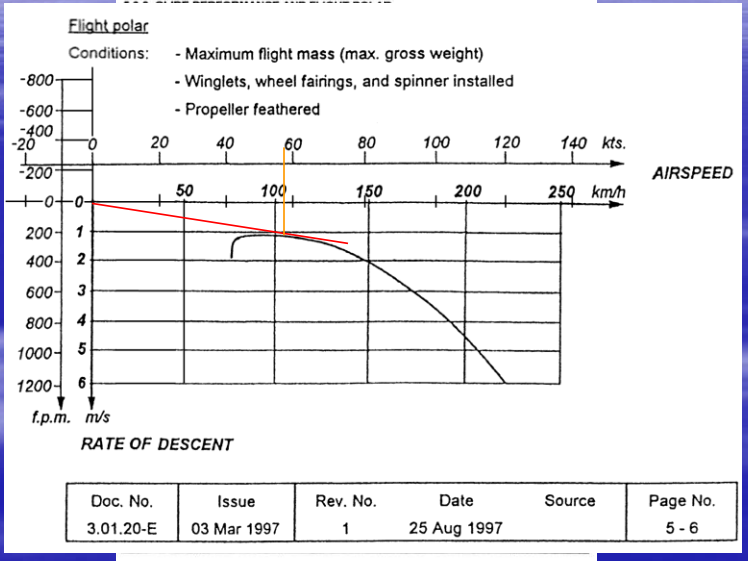


From “So You Want to Fly Gliders”

Xtreme Glider Polar



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Xtreme Glide Ratios (Calm Air)

- Best L/D (per manufacturer) – 27 to 1
  - 57 knots, Clean, Dry, Engine Off, Propeller Feathered, Cowl Flaps Closed, Winglets On, Tie-Down Rings off, Good Pilot Technique, Etc.
  - Article in 4/2004 issue of Soaring magazine by Dick Johnson calculated a Best L/D of 67 knots with a 24 to 1 glide ratio for a turbo model with a towing kit and lights.
- Other glide ratio estimates from Joachim H Schneibel, Soaring magazine article (4/2005)
  - Engine off but propeller windmilling. – 17 to 1
  - Propeller feathered - 1st notch of spoiler. – 10 to 1
  - Propeller feathered - Full spoilers. – 6 to 1

Safe Engine-Off in Xtreme

- **ECA/Sporty's Academy Policy**: Flight operations with the engine shut off must remain within gliding distance of a suitable airport at all times.
- If our theoretical best glide ratio is 27 to 1, how should we use this to determine if we are within a safe gliding distance from a suitable airport?
- What factors must we consider?

Sinking Air in the Xtreme (Uncompensated)

Glide Ratios in Sinking Airmass

Xtreme	Glide Ratio	27 to 1		
	Best Glide Speed	57 knots	0.95 nm / min	5776 feet / min
	Sink Rate (calc)	214 feet / min		

Airmass Sink	Glider Sink in Airmass	Actual Glide Ratio	Amount of Decrease
100 feet / min	314 feet / min	18.4	32%
200 feet / min	414 feet / min	14.0	48%
300 feet / min	514 feet / min	11.2	58%
400 feet / min	614 feet / min	9.4	65%
500 feet / min	714 feet / min	8.1	70%
600 feet / min	814 feet / min	7.1	74%
700 feet / min	914 feet / min	6.3	77%
800 feet / min	1014 feet / min	5.7	79%
900 feet / min	1114 feet / min	5.2	81%
1000 feet / min	1214 feet / min	4.8	82%
1100 feet / min	1314 feet / min	4.4	84%
1200 feet / min	1414 feet / min	4.1	85%
1300 feet / min	1514 feet / min	3.8	86%
1400 feet / min	1614 feet / min	3.6	87%
1500 feet / min	1714 feet / min	3.4	88%

Headwind in Xtreme (Uncompensated)

Glide Ratios in Headwind (Simple Version)

Xtreme	Glide Ratio	27 to 1		
	Best Glide Speed	57 knots	0.95 nm / min	5776 feet / min
	Sink Rate (calc)	214 feet / min	0.0352 nm / min	2.11 knots

Does NOT Account for Technique of Adding Half the Headwind Speed

Headwind Component	Groundspeed at 57 Knots Indicated	Actual Glide Ratio	Amount of Decrease
5 knots	52 knots	24.6	9%
10 knots	47 knots	22.3	18%
15 knots	42 knots	19.9	26%
20 knots	37 knots	17.5	35%
25 knots	32 knots	15.2	44%
30 knots	27 knots	12.8	53%
35 knots	22 knots	10.4	61%
40 knots	17 knots	8.1	70%
45 knots	12 knots	5.7	79%
50 knots	7 knots	3.3	88%
55 knots	2 knots	0.9	96%
60 knots	-3 knots	-1.4	105%

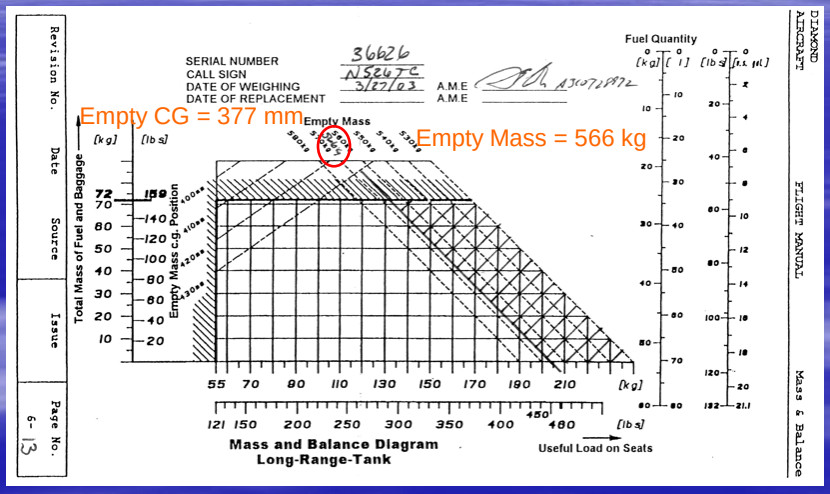
Planning Considerations for within Gliding Distance

- If possible, stay upwind of the airport.
  - Not always possible with our airport to stay directly upwind due to airspace.
  - Your choice of location within the practice area should be influenced by the wind.
- You can also select another suitable airport to use as your emergency landing location.

Visual Cues / Techniques for Determining within Gliding Distance

- While gliding toward airport, maintain correct final glide speed and note location and trend of airport on canopy.
  - Airport moving up on canopy – No chance of making it.
  - Airport staying in same place – Might make it if conditions remain the same, but no margin for error and no altitude for setting up landing upon arrival.
  - Airport moving down on canopy – Good chance of making it. Available altitude upon arrival depends on how low it is moving.
- While gliding toward airport, place the airport on the nose and maintain its position on the canopy by adjusting pitch. Note your airspeed.
  - Airspeed below appropriate final glide – No chance of making it.
  - Airspeed at appropriate final glide– Might make it if conditions remain the same, but no margin for error and no altitude for setting up landing upon arrival.
  - Airspeed above appropriate final glide– Good chance of making it. Available altitude upon arrival depends on how much faster and when you slow to the appropriate speed.

Xtreme Weight & Balance



Important Weight Limitations on Xtreme

- Max Takeoff Mass (Weight) – 770 kg (1698 lbs.)
- Maximum Load on Either Seat – 110 kg (243 lbs.)
- Maximum in Baggage Compartment – 12 kg (26 lbs.)
- Permissible CG Range – 318mm-430mm (12.52”-16.93”) Aft of Datum
  - Datum is at the leading edge of the wing at the root rib.
- Minimum Useful Load on the Seats – 55 kg (121 lbs.)
  - Solo flight with a pilot weighing less than 70 kg (154 lbs.) requires a thorough review of the weight & balance.

Xtreme V-Speeds

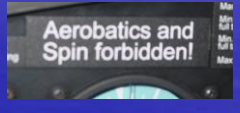
HK 36 TC V-Speeds from AFM for Serial Number 36626 (N526TC)

Airspeed		IAS knots
V_{NE}	Never exceed speed.	141
$V_{NO(RA)}$	Maximum structural cruising (normal operating)/Rough air speed.	113
V_A	Maneuvering speed (max gross weight).	95
V_{ABF}	Maximum admissible speed with air brakes fixed in half extended position.	81
V_R	Rotation speed.	43
V_{LOF}	Aircraft liftoff speed.	49
V_Y	Best rate of climb speed.	57
V_X	Best angle of climb speed.	51
	Recommended lowest airspeed for approach. (Weather conditions may require a higher speed for safety.)	57
	Best glide ratio speed (maximum lift drag ratio).	57
	Minimum descent rate speed (232 ft./min.).	52
V_{S0}	Stall speed with air brakes retracted (0º bank).	42
V_{S1}	Stall speed with air brakes extended (0º bank).	44

Other Xtreme Limitations

- Certified in the Utility category. Aerobatics *and* spins are forbidden.

Table of maximum permissible load factors:	Maximum G's	
	V_A	V_{NE}
positive	5.30	4.00
negative	-2.65	-1.50



- Day-VFR operations only.
- May not be towed aloft.
- For flutter safety, V_{NE} decreases above 6500' PA
- Solo ops from left seat only.

Pressure altitude	Never exceed speed (V_{NE})
feet	kts.
0 to 6500	141
6500 to 9800	133
9800 to 13100	126
13100 to 16400	119
16400 to 19600	113

Xtreme Takeoff Performance

Diamond AIRCRAFT — HK 36 TC AIRPLANE FLIGHT MANUAL — Performance

5.3.3 TAKE-OFF CHARTS

Conditions:
- Full throttle
- Maximum flight mass (max. gross weight)
- Propeller setting: TAKE-OFF
- Rotation at approx. 80 km/h (43 kts. / 50 mph)
- Lift-off speed approx. 90 km/h (49 kts. / 56 mph)
- Speed during climb approx. 95 km/h (51 kts. / 59 mph)
- Level runway, asphalt surface

s_1 = Take-off roll; s_2 = Take-off distance to clear a 15 m (50 ft.) obstacle

Head-wind comp. [kts.]	OAT [°C]	Pressure altitude above MSL [m] / QFE [hPa]							
		0/1013		400/966		800/921		1200/877	
		s_1 [m]	s_2 [m]	s_1 [m]	s_2 [m]	s_1 [m]	s_2 [m]	s_1 [m]	s_2 [m]
0	0	175	301	198	334	224	372	254	417
	15	201	338	227	377	258	420	294	471
	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	474	[illegible]	533
5	0	[illegible]	[illegible]	160	[illegible]	[illegible]	[illegible]	209	355
	15	[illegible]	[illegible]	185	[illegible]	[illegible]	[illegible]	[illegible]	403
	30	186	321	212	360	243	405	279	457
10	0	111	209	126	236	145	265	166	297
	15	128	238	150	268	168	301	195	340
	30	148	270	170	302	196	342	227	387

Metric

WARNING

A grass surface will extend the take-off distances by at least 20 %, depending on the characteristics of the ground (softness, grass height).

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Diamond AIRCRAFT — HK 36 TC AIRPLANE FLIGHT MANUAL — Performance

Head-wind comp. [kts.]	OAT [°F]	Pressure altitude above MSL [ft.] / QFE [inHg]							
		0/29.9		1310/28.5		2620/27.2		2940/25.9	
		s_1 [ft.]	s_2 [ft.]	s_1 [ft.]	s_2 [ft.]	s_1 [ft.]	s_2 [ft.]	s_1 [ft.]	s_2 [ft.]
0	32	574	988	650	1096	735	1220	833	1386
	59	659	1109	745	1237	846	1378	965	1545
	86	751	1240	850	1385	971	1555	1109	1749
5	32	463	833	525	928	600	1037	686	1165
	59	535	938	607	1050	692	1175	794	1322
	86	610	1053	696	1181	797	1329	915	1499
10	32	364	686	413	774	476	869	545	974
	59	420	781	492	879	551	988	640	1115
	86	486	886	558	991	643	1122	745	1270

WARNING

A grass surface will extend the take-off distances by at least 20 %, depending on the characteristics of the ground (softness, grass height).

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Xtreme Cruise Performance in Power Cruise Mode

Conditions:
- Propeller speed: 2200 RPM
- Pressure altitude: 1500 meters (4900 ft.)

manif. press.	fuel consumption		cruising speed			max. duration	range			fuel tank
in. Hg	l/h	US gal. per hr.	km/h	kts.	mph	h:min	km	naut. miles	stat. miles	
23	15	4.0	170	92	106	3:36	612	330	380	55 l
						5:08	873	471	542	79 l
22	13	3.4	160	86	99	4:09	665	359	413	55 l
						5:55	948	512	589	79 l

NOTE

It is generally recommended for a fast cruise that the propeller speed is set at 2400 RPM and that the manifold pressure is at least 0.7 inHg under the maximum obtainable. This reduces the fuel consumption considerably whilst hardly affecting the cruising speed.

For an economical cruise it is recommended that the RPM is set between 2300 and 2200 and manifold pressure 1 to 2 inHg under the maximum obtainable.

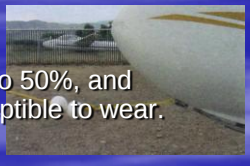
Launch Method Specific Operations

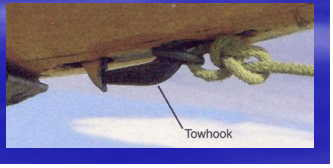
Aerotow

- Aerotow involves an airplane pulling the glider into the air using a towrope.
  - Rope length is typically around 200'.
  - Tow hook in nose is preferred.
- During tow, the glider pilot is flying formation with the towplane attempting to follow his track exactly.
- Upon reaching the desired altitude, the glider pilot releases his end of the tow rope and turns away from the airplane.

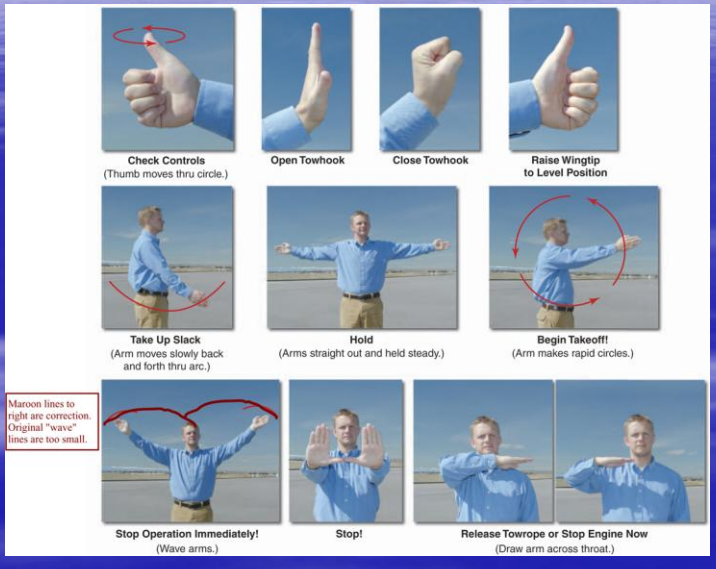
Aerotow

- Preflight on an aerotow flight may require a preflight of the tow equipment.
- Proper towrope or weak link strength.
  - Per 91.309, strength of the towrope or weak links must 80-200% of the max cert weight of the glider.
  - If using weak link, one at each end of rope. Towplane end should be stronger but not more than 25% stronger.
- No knots in rope.
  - A knot in the towrope reduces its strength by up to 50%, and causes a high spot in the rope that is more susceptible to wear.
- Proper operation of the tow hook release.
- Proper ring for the tow hook release.
  - Tost
  - Schweizer

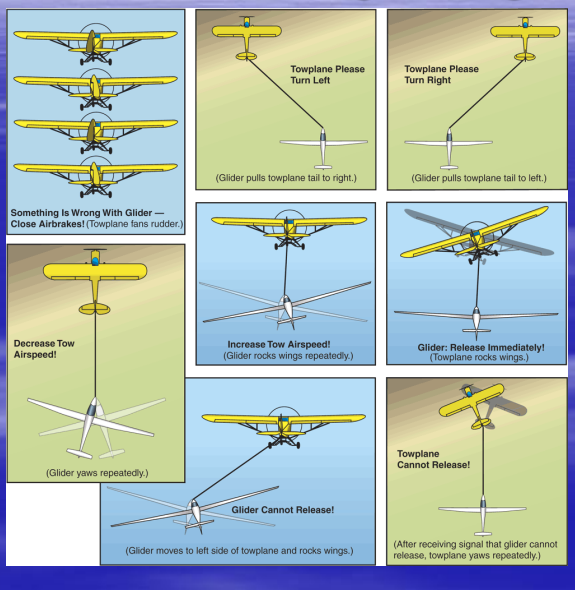




Aerotow – Pre-Launch Signals



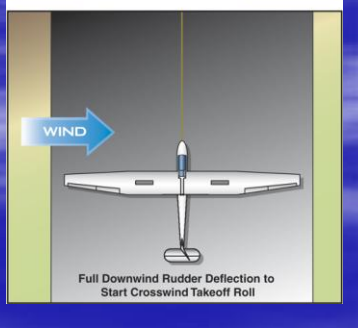
Aerotow – In-Flight Signals



Visual Signals in Action from "So You Want to Fly Gliders"

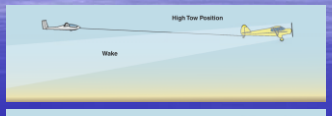
Aerotow – Takeoff

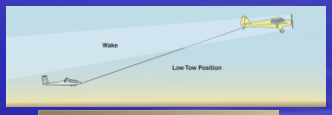
- After completion of checks, review of emergency procedures, and appropriate signals, tow pilot adds power.
- Glider will takeoff first but do not climb until towplane lifts off.
- Crab to maintain appropriate crosswind correction while over runway.

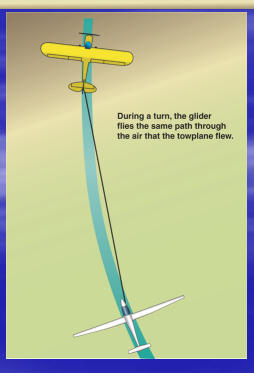


Aerotow – On Tow

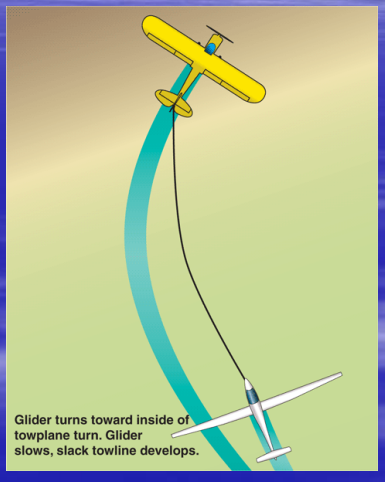
- High Tow
  - Preferred for climbing out.
  - OK view of the towplane.
  - Some protection if the towrope breaks or is released by the towplane.
    - The towrope falls below the glider.
- Low Tow
  - Better view of towplane but more risk.
  - Used for cross-country & level-flight tows.
- Turns on Tow
  - Must follow same path as towplane.
  - Should slightly see side of towplane inside of turn.



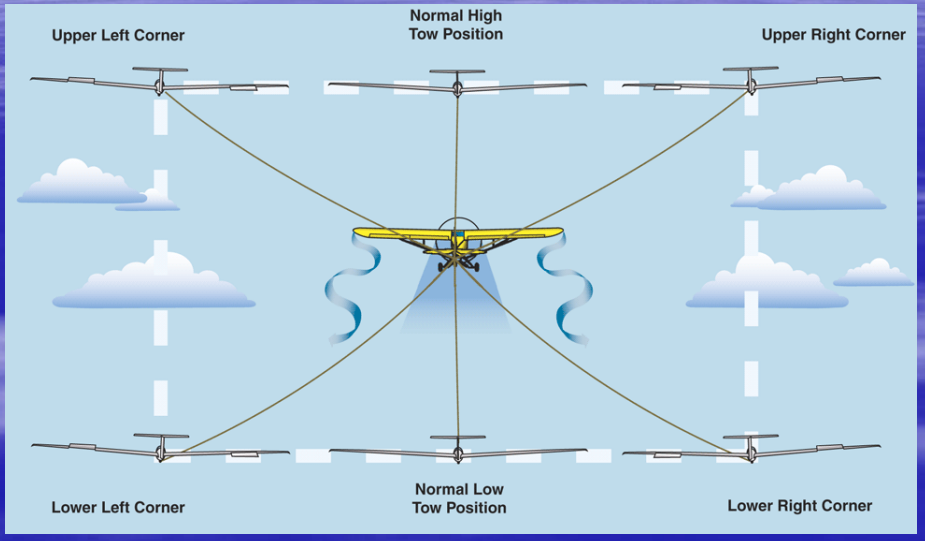




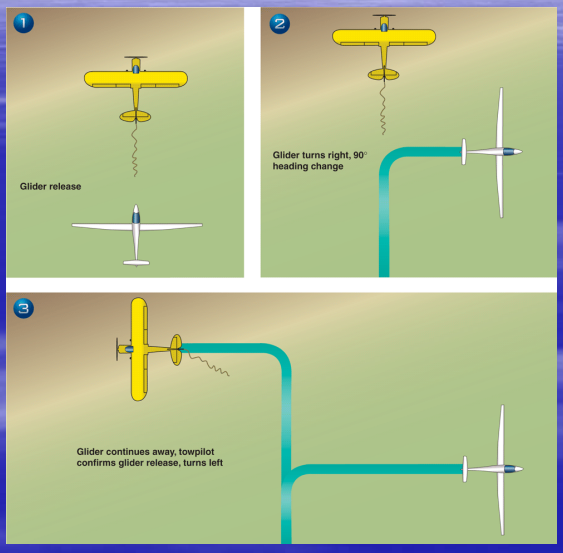
Aerotow – Faulty Turns



Aerotow – Boxing the Wake

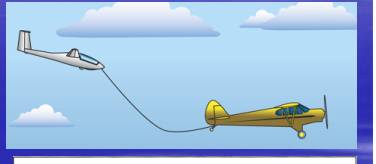


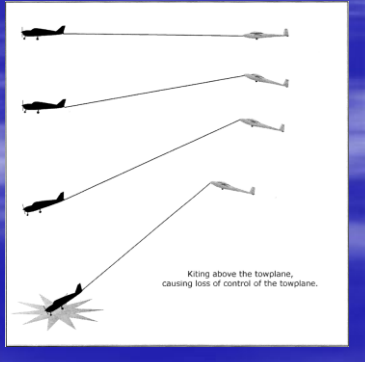
Aerotow – Release Sequence



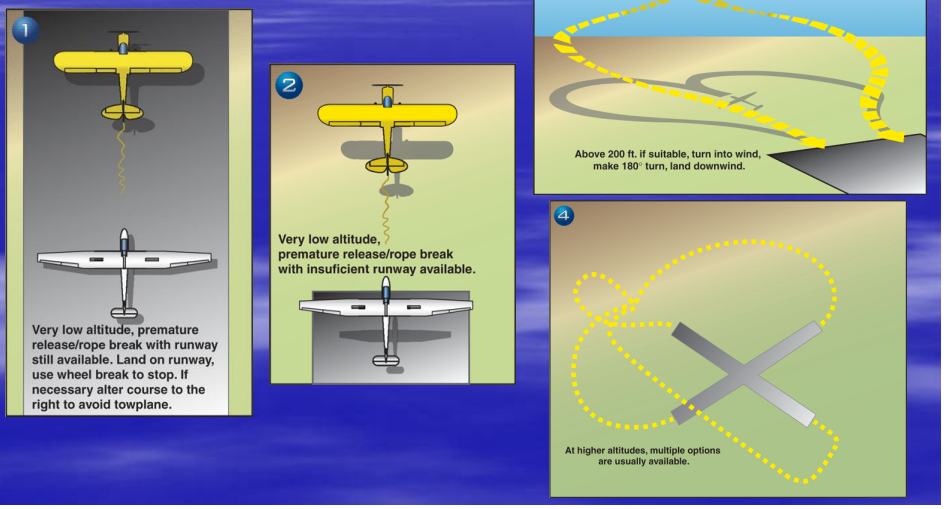
Aerotow – Abnormalities & Emergencies

- Slack line.
  - Can entangle and damage the glider or towplane if severe.
  - Correct by slowing the glider.
- High on tow.
  - Can cause slack line on recovery.
  - Can upset towplane if excessive.
  - Correct by slowing & descending, or if towplane is not in sight, release.
- Release failure.
  - Signal towplane and he will release.
  - Double failure may require landing on tow.
- PT3 – Next Slide.





Aerotow – PT3-Premature Termination of The Tow

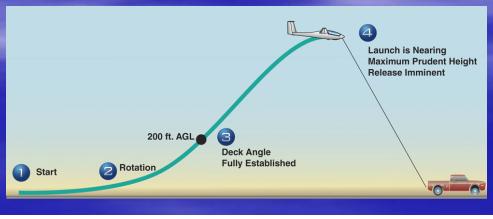


Ground-Tow

- Also called ground launch.
- Modern ground-tow utilizes either an automobile or a winch on the ground to propel the glider into the sky.
  - Bungee cord type systems were used in the past.
- Altitude is limited by cable or rope length and the size of the area.
  - Attachment of cable / rope to CG tow hook is preferred.
- Can be the most economical launch method.

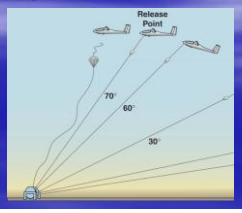
GT – Takeoff and Tow

- Speed for a tow vehicle must be calculated based upon conditions and glider limitations.
- Signals can be critical due to distances involved.
- Rate of initial pitch change can be critical.
  - Too fast, danger if PT3 and potential for stall.
  - Too slow, glider may accelerate over limit speed.
- Pitch should reach maximum at approximately 200'.



GT – Takeoff and Tow

- Track the runway centerline throughout the process.
- The pitch attitude/airspeed relationship during ground launch is unique.
  - Given sufficient tow power, pulling back on the stick tends to increase airspeed, and pushing forward tends to reduce airspeed.
  - This is opposite of the normal pitch/airspeed relationship.
- Begin to level-off at the maximum altitude and nearly over the tow apparatus.
- Lower the nose slightly to decrease cable tension for the release.



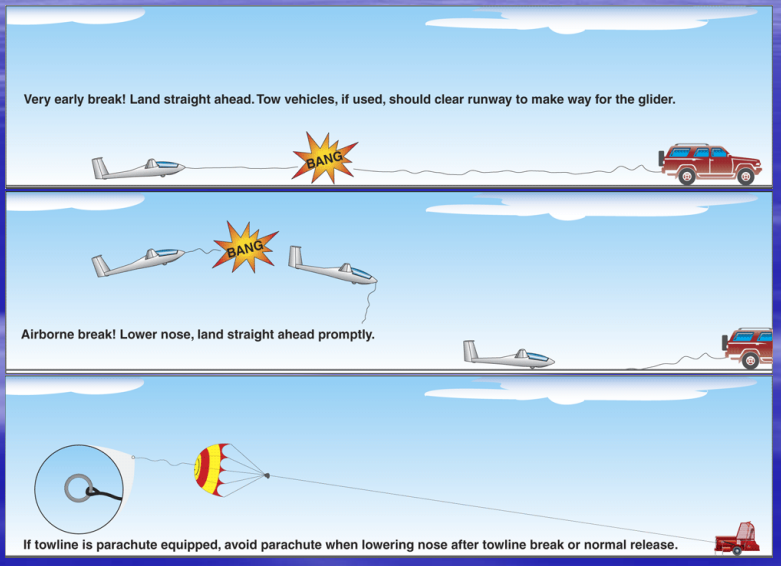
GT – Abnormalities & Emergencies

- Inappropriate tow speed.

- Release failure.

- PT3 – Next Slide.

GT – PT3-Premature Termination of The Tow



Self-Launch

- Often called a motorglider.
- Has an engine to power it into the air, which is shut off for soaring flight.
- The propeller may be designed to feather or the blades may tuck away into the nose.
  - Other designs stow the entire motor and propeller assembly in the fuselage.
- Contrary to popular belief, you must have a glider rating or self-launch solo endorsement to fly any motorglider, even with the engine running. Legally, it is not an airplane.

SL – Takeoff and Climb

- Many can be taxied to the runway solo.
- Before takeoff checks and briefing like an airplane.
  - Critical altitudes for an engine failure are different.
- Takeoff procedures may vary depending on location of propeller thrust line and gear design.
  - Xtreme has tricycle gear and midline thrust like many airplanes.
- Climbout will be at V_Y until at a safe altitude.

SL – Airborne Shutdown and Restart

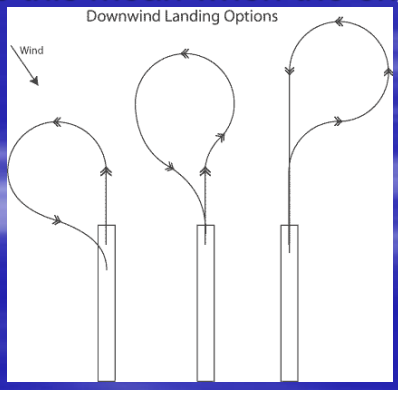
- Before shutdown, are you at a safe altitude and location to perform this operation?
- Follow the manufacturer's recommend checklist procedures for shutdown and securing.
- Allow sufficient altitude for a restart.
- First step in any restart is to ensure you are over or heading toward a safe landing area.
- Follow the checklist for restart.

SL – Abnormalities & Emergencies

- Propeller problems.
  - Overspeed.
  - Inability to feather.
  - Inability to unfeather.
  - Inability to stow or unstow.
- Electrical problems.
- Fire.
- PT3 on next slide.

SL – PT3-Premature Termination of The Tow (aka: Engine Failure)

- Climbing at V_Y, you are close to L/D_{MAX} in many motorgliders.
  - What does this mean when the engine quits?



Soaring Weather

Preflight Weather Planning

- METARs
- TAFs
- Area Forecast
- Winds and Temperatures Aloft
- Weather Charts
- Lifted Index and K-Index Chart
- Soaring Forecasts

Sources of Thermal Index and Soaring Weather Information

- http://www.soarforecast.com/
- http://www.drjack.info/BLIP/RUC/
- http://rucsoundings.noaa.gov/
- http://rucsoundings.noaa.gov/gifs/reply-skewt.cgi?data_source=Op40&lon=-104.67&lat=39.87&airport=ILN

Atmospheric Stability Review

Adiabatic Process

- The process by which fixed relationships are maintained during changes in temperature, volume, and pressure in a body of air without heat being added or removed from the body
- What does this mean?
- How does this relate to air movement?

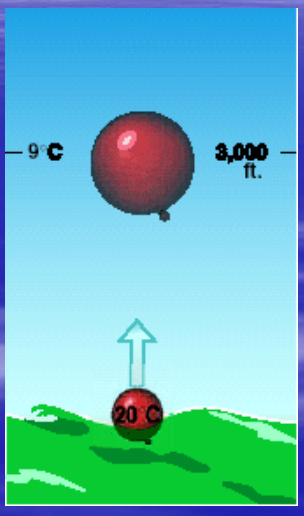
Lapse Rate

- Change in temperature per unit of altitude
- Standard Atmosphere / Average Lapse Rate
  - 2° C/1,000'
- Dry Adiabatic Lapse Rate
  - 3° C/1,000'
- Saturated / Moist Adiabatic Lapse Rate = Varies based upon temperature
  - As low as 1° C / 1,000' in very warm air
  - Approaches 3° C / 1,000' in very cold air
- Actual Lapse Rate
  - The rate that is measured via a sounding
- If the actual lapse rate is greater than 3° C/1,000' it is considered to be an unstable atmosphere

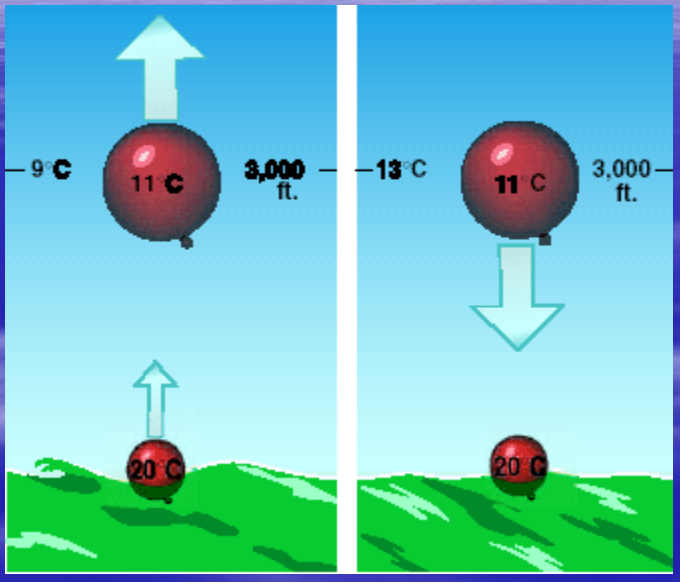
Stability of Lifted Air

- Cools faster or is cooler than the surrounding air it is considered Stable
- Same temperature as surrounding air it is Neutrally Stable
- Cools slower or is warmer than the surrounding air then it is Unstable

Is This a Stable or Unstable Airmass?



Unstable and Stable Air Masses



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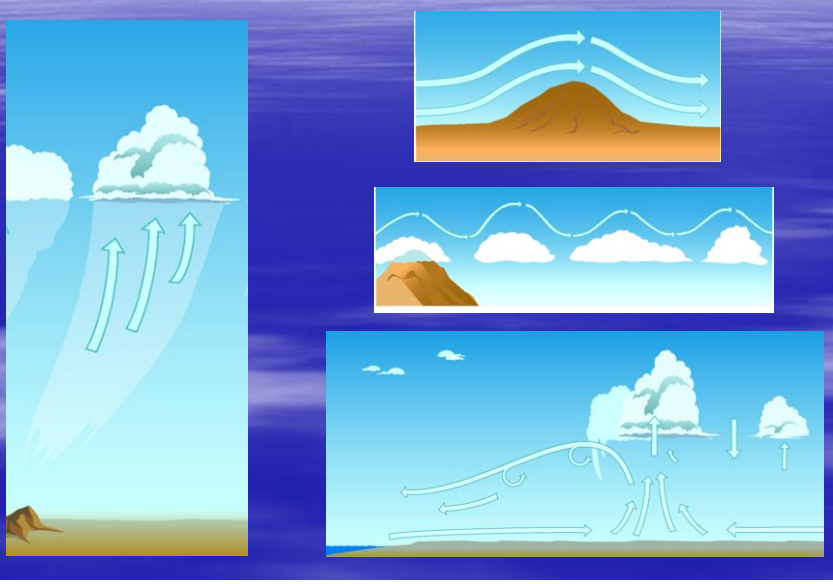
- http://rucsoundings.noaa.gov/gifs/reply-skewt.cgi?data_source=Op40&lon=-104.67&lat=39.87&airport=ILN

Sources of Lift

Sources of Lift



Lift Strength

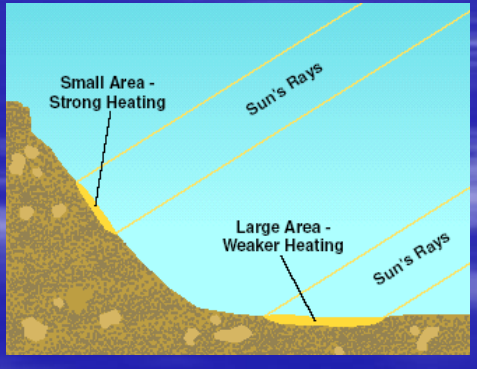
- Strength of the lift is defined in knots
  - Vertical knot
- 1 knot = 1 nautical mile per hour
  - = 6076 feet per hour
  - = 6076 feet per 60 minutes
  - = 101 feet per minute
- 1 knot of lift is approximately 100 fpm

Thermals

- An updraft in a small-scale convective current
  - Requires low-level heating
- Requires an unstable lapse rate to be sustained

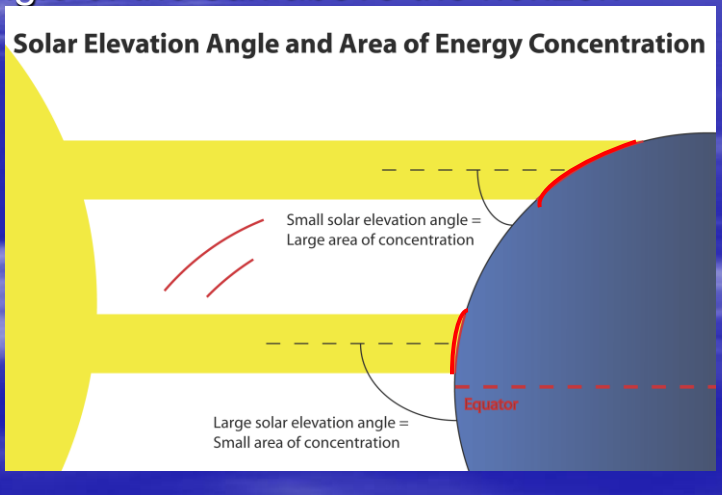
Recognizing Thermals

- Terrain
  - Dark areas that release heat
- Sun Angle
  - Hilly terrain
  - Winter vs. Summer



Solar Elevation Angle

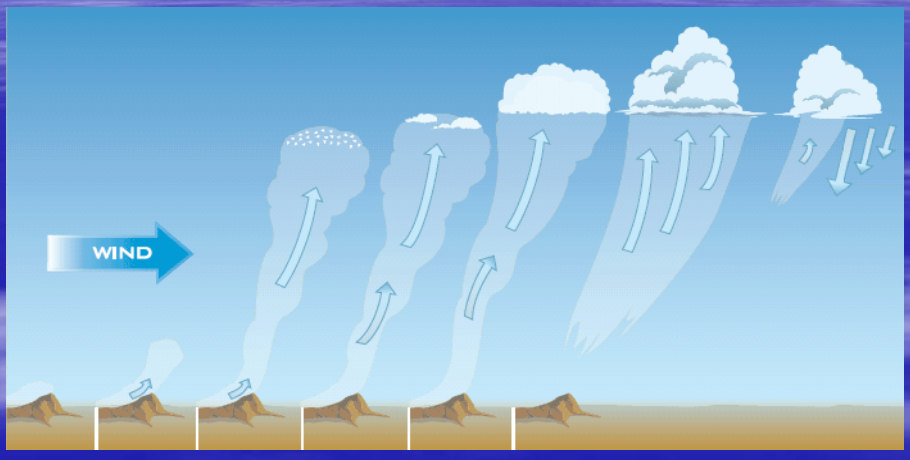
- Angle of the sun above the horizon



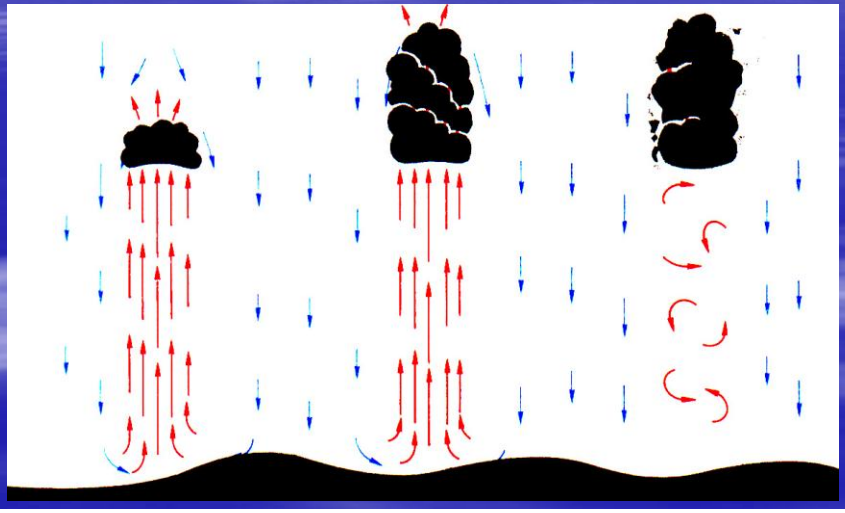
Recognizing Thermals

- Dust & Smoke
  - Converging surface winds
- Birds
- Cumulus clouds
  - Mark the top of the rising thermal when sufficient moisture is present
  - Look for
    - Sharp fine edges
    - Concave bases
    - Building tops

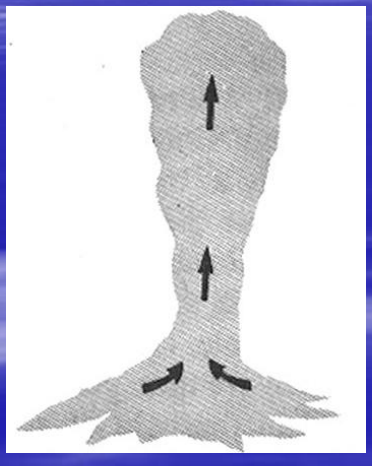
Life-Cycle of a Thermal



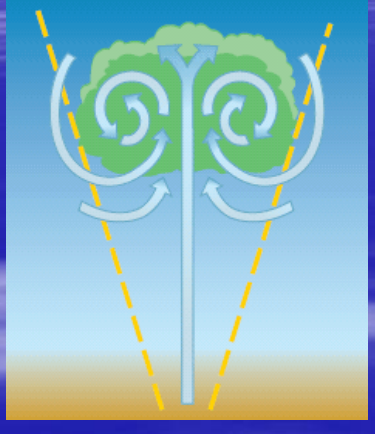
Thermals

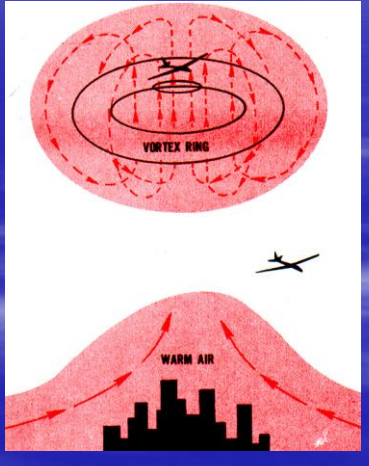


Chimney, Column, or Plume Thermal Model



Bubble or Vortex Ring Thermal Model





Thermal Cross-Section

- Looking down from top of thermal
- Darker green indicates stronger lift in this diagram
- Red indicates sink

Thermal Streets

- Cloud streets
- Rows of thermals that develop
  - Recognized by lines of cumulus clouds
- Usually found parallel to the wind
- Usually develop after a cold front passes
- Can soar down a straight line

Clouds as Stability and Thermal Indicators

Stratus Clouds

Cumulus Clouds

Cumulus Clouds

Cirrus Clouds

Cirrus Clouds

Altocumulus Clouds

Cirrocumulus

Stratocumulus Clouds

Towering Cumulus Clouds

Cumulonimbus Clouds

Mammatocumulus Clouds

Credits for Cloud Pictures

- Previous pictures from NOAA historical collection and from Dick Eckels, Glider Instructor & DPE (Sporty's Academy & CCSC)

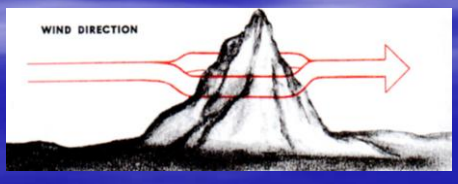
Other Sources of Lift

Ridge Soaring

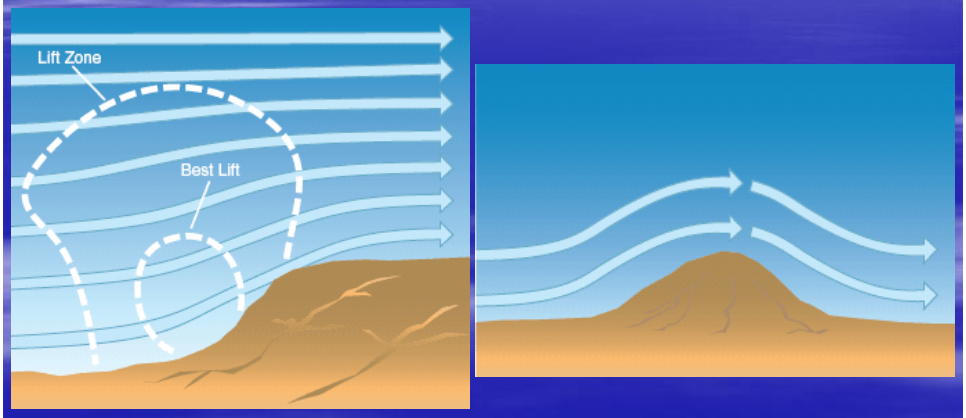
- Flight in rising air along a ridge or hill that is strong enough to support flight in a glider
- Orographic lifting on the windward side of the ridge

Orographic Lifting

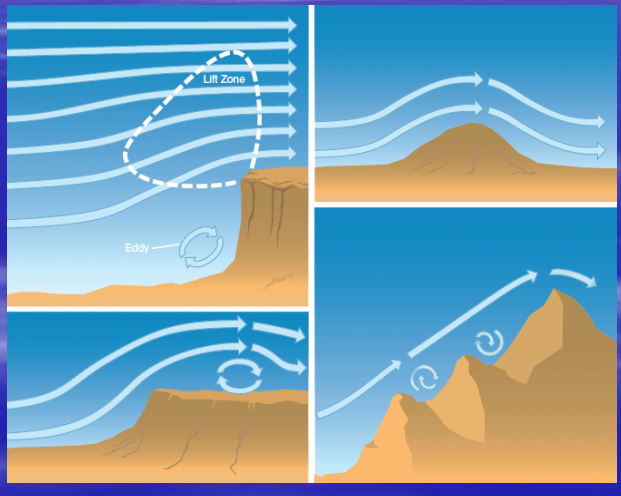
- Occurs more often along a ridge than a single hill or mountain
  - The air will flow around a single hill
- Wind needs to be perpendicular to the ridge
  - Beyond 30° off and lift is spoiled



Air Flow Over a Ridge



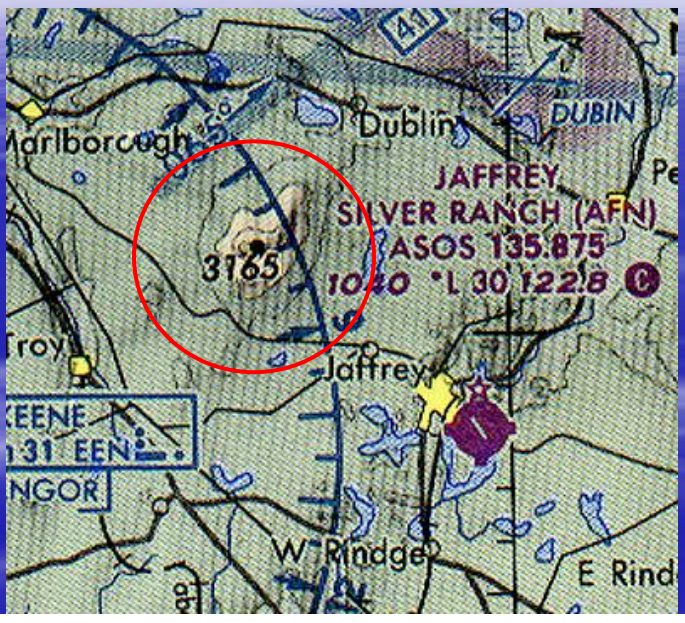
Eddy Currents



Steepness

- Slope of 1 to 4 is best
  - Too steep and eddies start to form, too shallow and little or no lift
- Ridge continuity can affect lift
  - Randomly scattered peaks disrupt airflow

Poor Orographic Lift

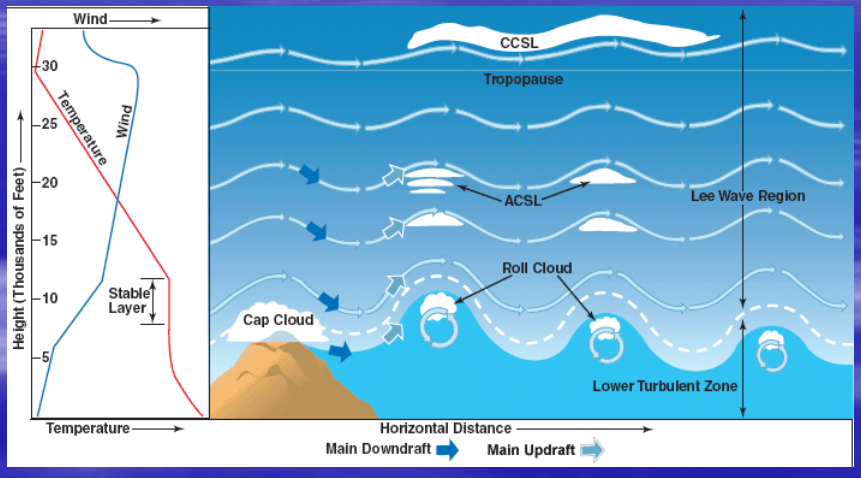


Good Ridge Lift

Mountain Waves

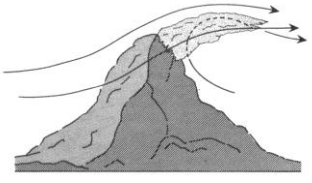
- Produced on the lee side of a mountain
  - Stable stream of air is disturbed by the mountain
- Wind at the summit must be greater than 15 to 25 knots and should increase at higher altitudes
  - Speed required depends on the height of the range
- Wind must be within 30° of perpendicular to the mountain
  - Must remain approximately the same direction with increasing altitude to sustain the wave

Mountain Wave



Telltale Wave Signs

- Pendant Cloud
  - Forms on the top of the mountain
- Roll Cloud
  - Under the rising bubble
- Standing Lenticular Clouds
  - Crests of the wave

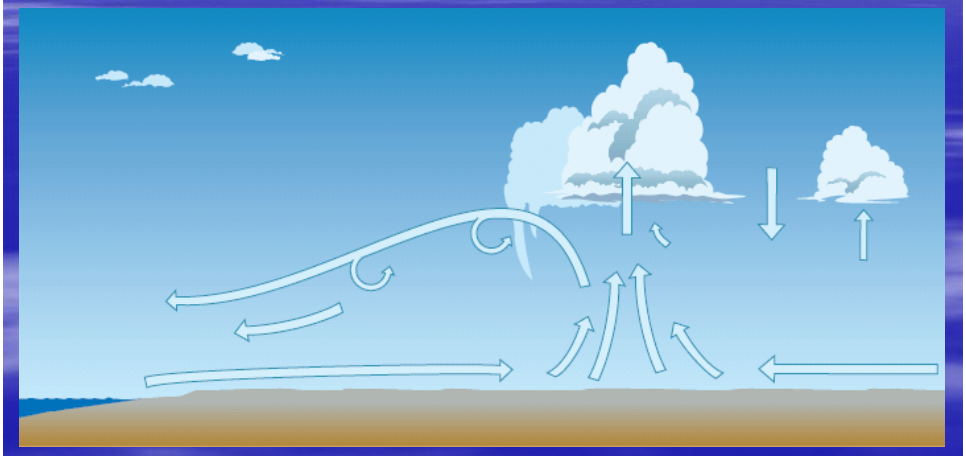


From “So You Want to Fly Gliders”

Sea Breeze Front

- Occurs near the collision of the cool moist air from the water and the dry heated air of the land
- Convergence lift

Sea Breeze Front



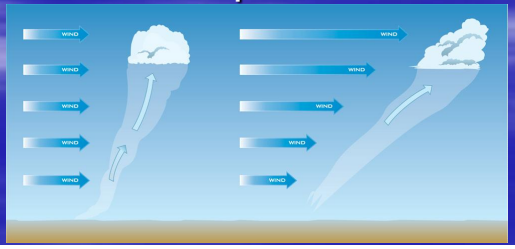
Thermalling

Thermalling

- Successful thermalling requires several steps:
  - Locating the thermal.
  - Entering the thermal.
  - Centering the thermal.
  - Leaving the thermal.

Locating the Thermal

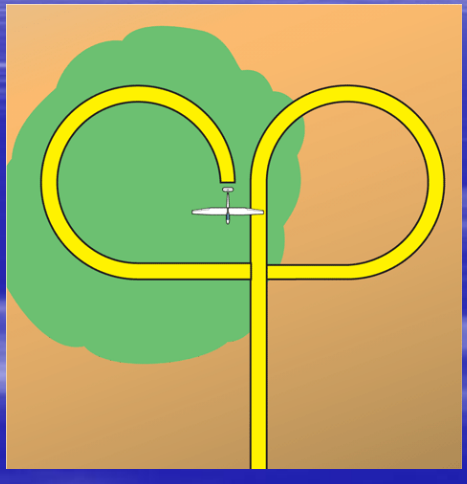
- Locating the thermal starts with the recognition signs we have previously discussed.
- Utilize your appropriate speed-to-fly while en route between thermals.
- Wind will influence the shape and location of the thermal.



Entering the Thermal

- Clear the area before entering a suspected thermal.
  - If another glider is circling in the thermal, circle in the same direction and keep an eye on him.
- Entry will be felt before it is seen on the vario.
- Roll into the thermal.
  - If you turn the wrong way, you will invariably be treated to sink.
    - Don't try to turn back the other way.
    - Use a correcting maneuver.

270° Correcting Maneuver



Centering the Thermal from “So You Want to Fly Gliders”

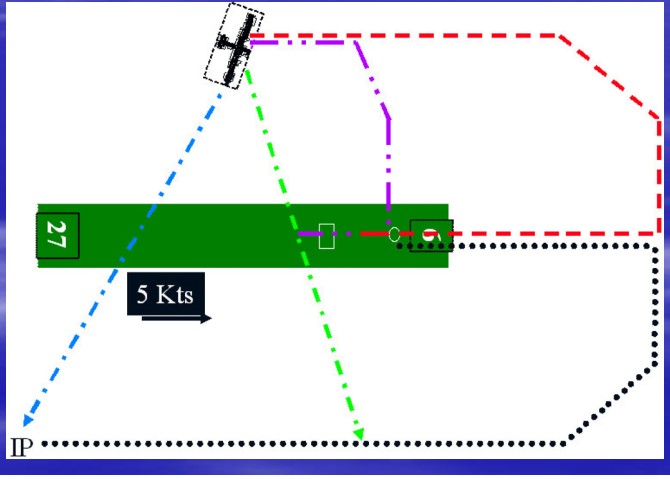
Leaving the Thermal

- When to leave a thermal?
- Thermal weakens.
- High enough.
- Lose thermal.
- Moving to next thermal for cross-country progress.
- Time to head home.

Returning for Landing

Landing

- Goal of a Glider Traffic Pattern



“So You Want to Fly Gliders”

Questions?

Glider Training at Sporty's Academy