

Sail Theory & Trim

Coasters Harbor Navy Yacht Club

www.nwc.navy.mil/chnyc

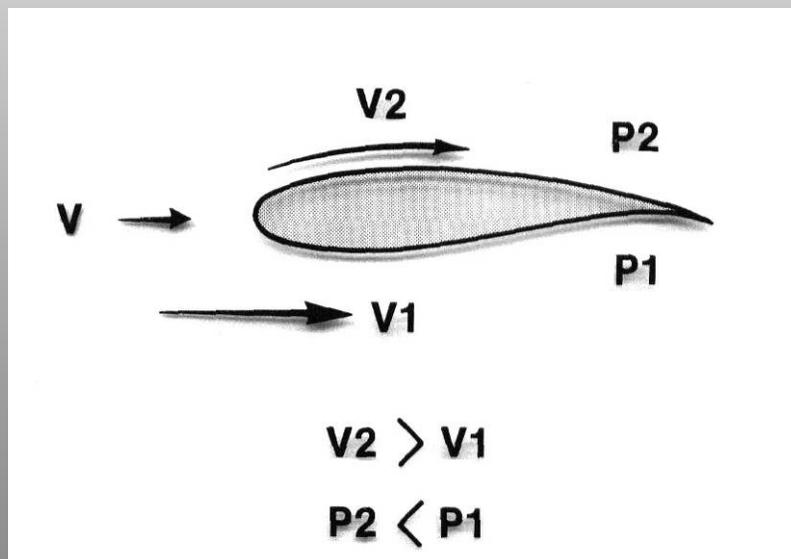


Sails Produce Power

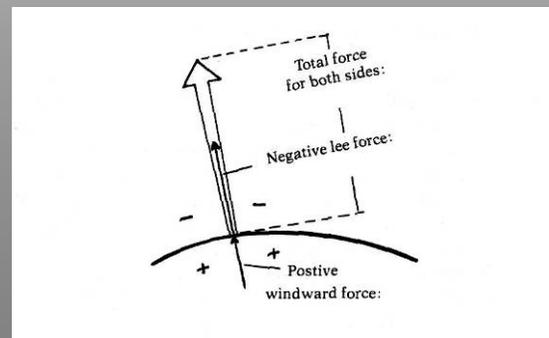
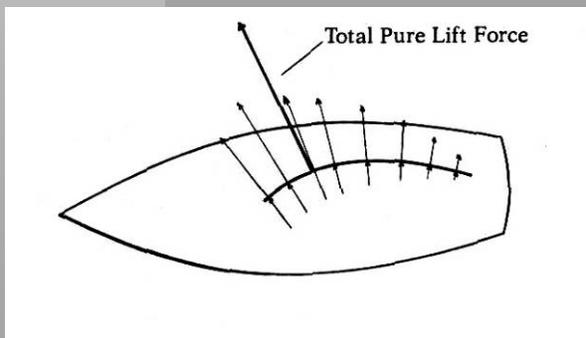
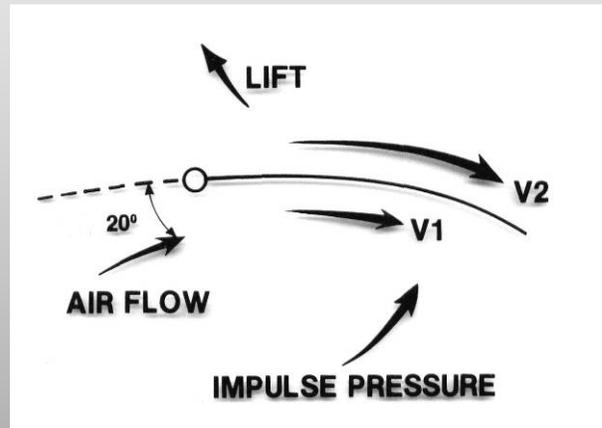
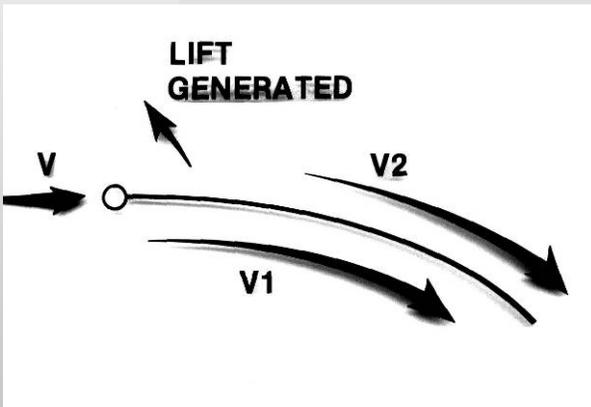
- **Air flows around sails**
 - Pressure and velocity on both sides
 - Differences exert force
 - Directional components
- **Two modes**
 - Lift pulls the boat forward
 - Pressure pushes the boat forward

Bernoulli Principle

- As velocity increases, pressure decreases
- In an airfoil, lift is generated



Aerodynamics

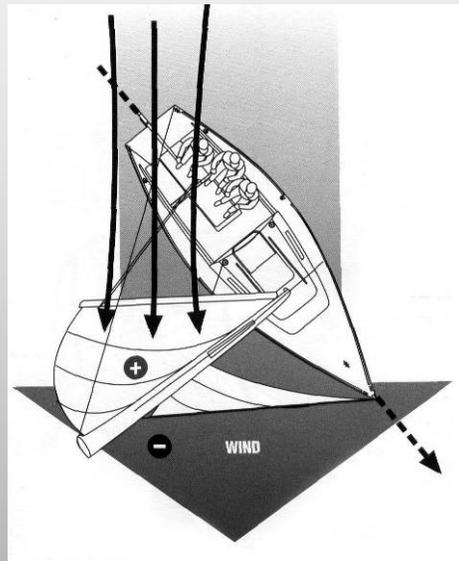


Sail: Flexible Membrane

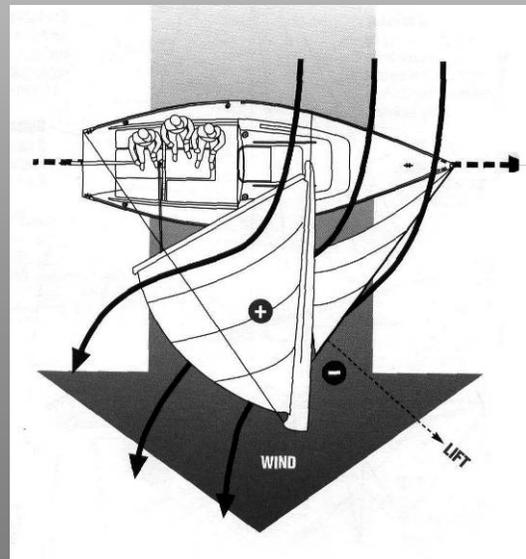
- **Direct the flow**
- **Flow is split to windward and leeward sides**
- **Pressure builds on windward side**
- **Flow is attracted to lower pressure areas**
 - **Leeward side**

How Sails Work

- **Push mode**
 - Wind coming from behind
 - Sail and boat are pushed forward through the water

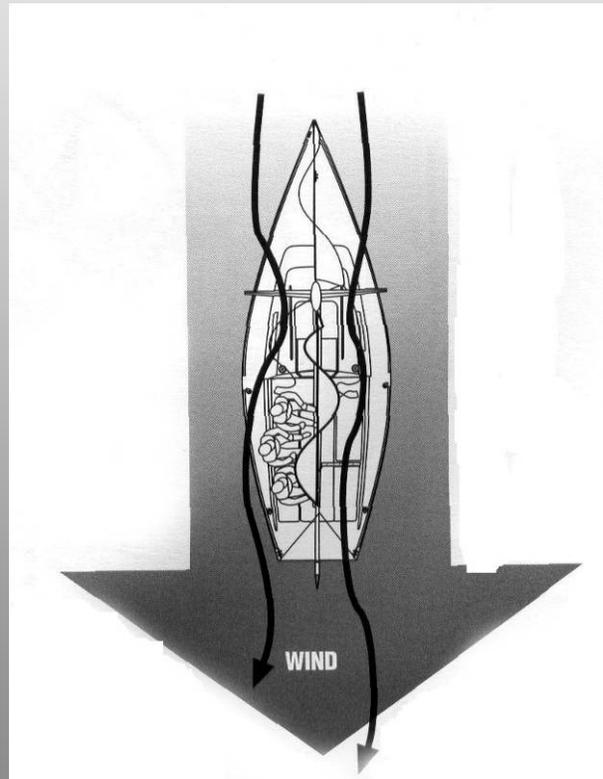


- **Pull mode**
 - Bend the wind
 - High pressure on one side (+) and lower pressure on the other (-)
 - Pulls the boat



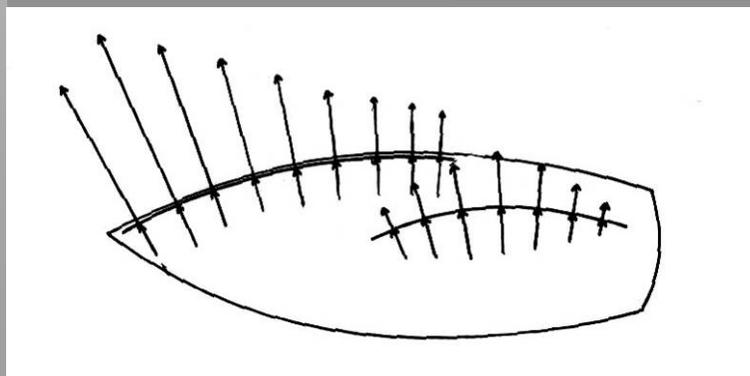
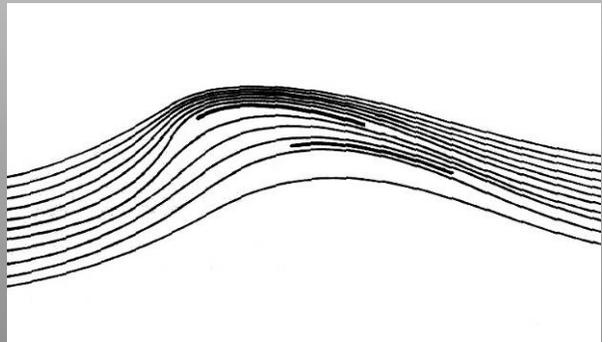
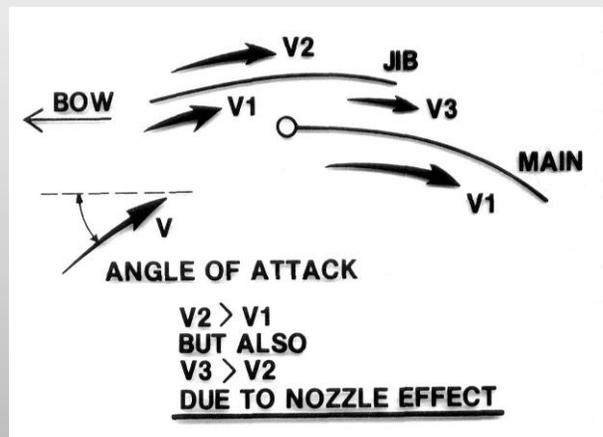
When Sails Don't Work

- **No difference in pressure = no flow**
 - No push
 - No pull
 - No go!
- **Sails flutter**
 - Luff
 - Irons
- **Eventually go backwards**



Sails Working Together

- Jib and main-sail work together as one big sail
- From the luff of the jib to the leech of the mainsail

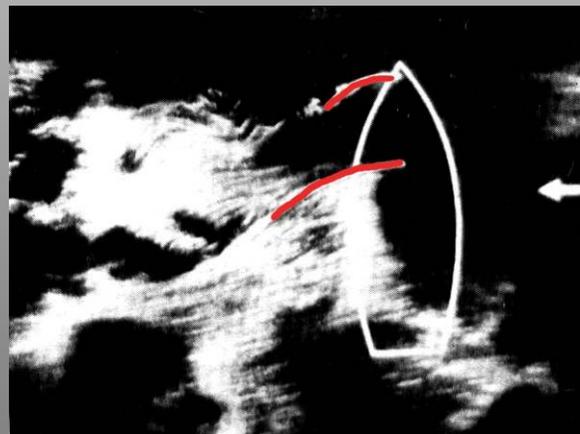
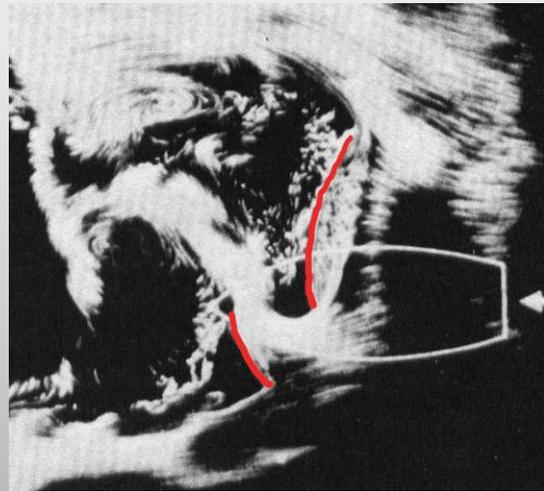


Wind Force (lbs per sq ft sail)

Knots	Wave	Wind	Force (PSF)
0	Like glass	Calm	0
1-3	Small ripples	Light air	.02
4-6	Small wavelets	Light breeze	.1
7-10	Larger wavelets	Gentle breeze	.3
11-16	Small waves & whitecaps	Moderate breeze	.7
17-21	Frequent whitecaps some spray	Fresh breeze	1.6
22-27	Large waves	Strong breeze	3.0

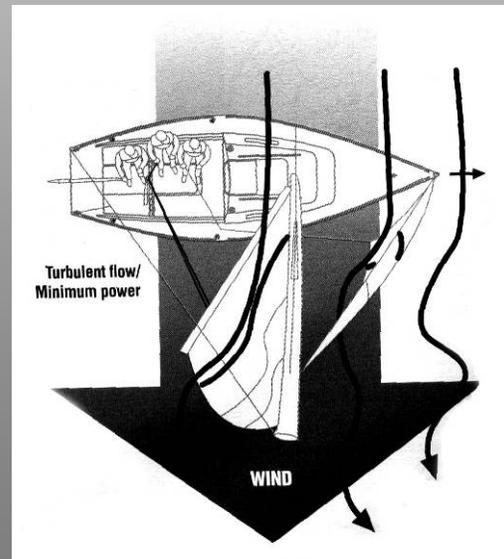
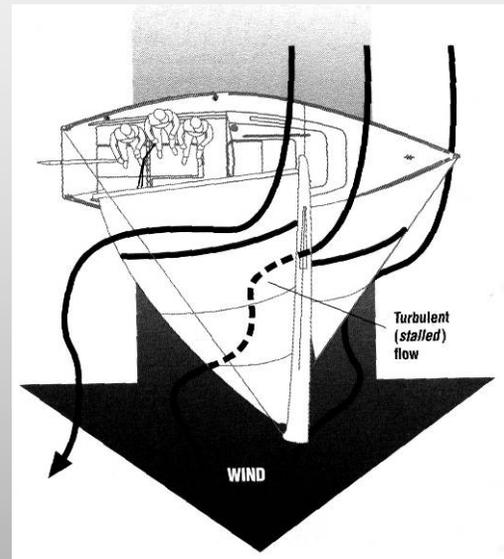
If You Could See The Wind

- **Envelops the boat**
- **Dynamic**
 - Speed
 - Direction
- **Complex patterns**
 - Flow
 - Eddies



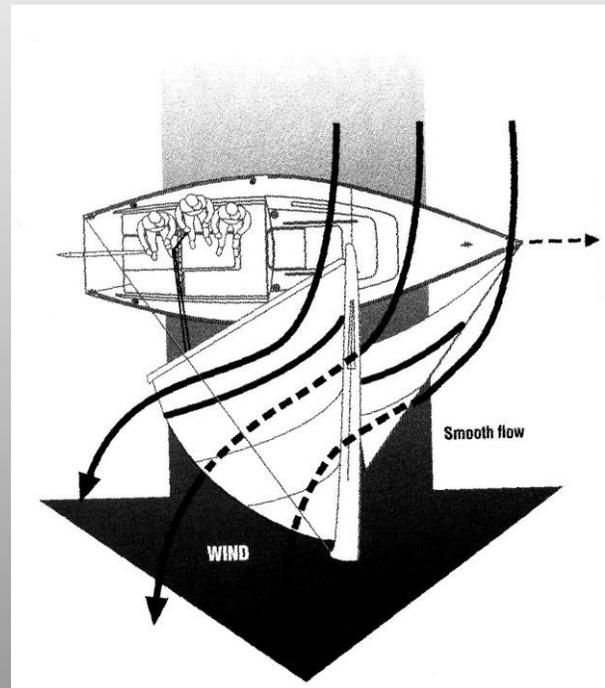
Trimming a Sail

- **Too tight**
 - Stalled flow
 - Reduced power
 - Difficult steering
 - Healing (tipping)
 - Ease the sails
- **Too loose**
 - Turbulent flow
 - Minimum power
 - Reduced speed
 - Trim the sails



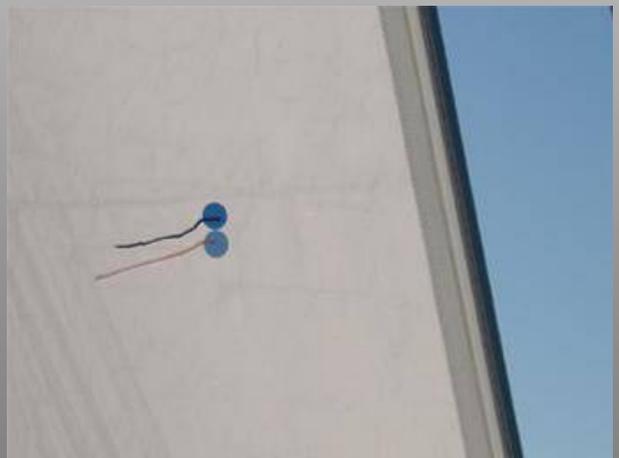
Trimmed Just Right

- **Smooth flow**
- **Optimum power**
- **Optimum speed**
- **Easy steering**
- **Well balanced**



Telltails

- Show flow
- Indicate when sail is properly trimmed

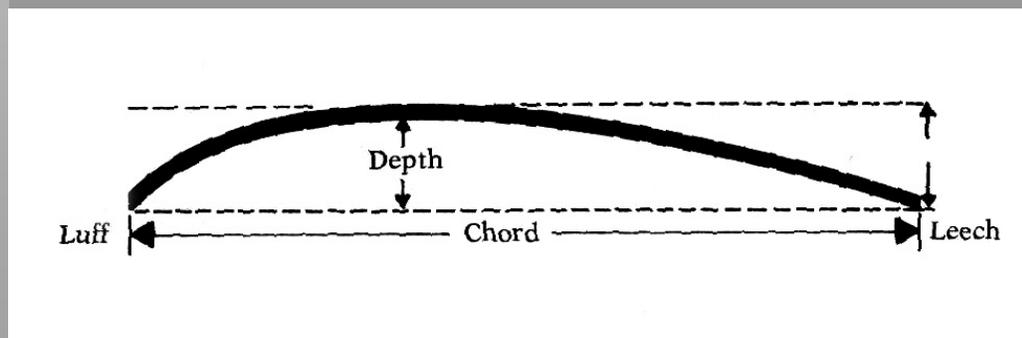
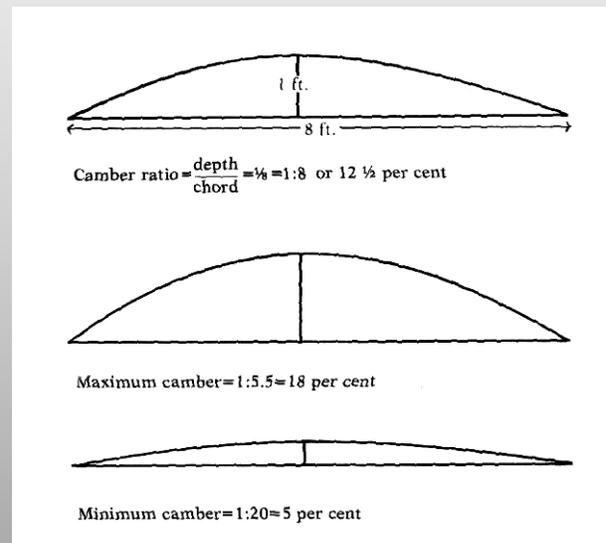


Striped Sails?



Camber Control

- **Sail concavity**
- **Smaller camber for high winds**
 - Tighten outhaul
 - Fairleads aft
- **Larger camber for light winds**
 - Loosen outhaul
 - Fairleads forward



Sail Controls

- **Running rigging adjusts shape and position**
- **Jib**
 - **Sheets**
 - **Fairleads**
- **Main**
 - **Sheet**
 - **Outhaul**
 - **Boom vang**
 - **Downhaul**
 - **Advanced**
 - **Cunningham**
 - **Backstay**
 - **Traveler**