#1: Prepare the boat

Before launching or leaving dock:
- **Good sails** → easier to trim right
  - Bad sails → hard to trim & inefficient
- **Clean bottom**
- **Rig in tune** (specs from class association, manufacturer, sail-maker)

#2: Trim the Boat

- **Fore-and-aft**
  - Weight out of the ends
  - Centered over keel/c'board
- **Side-to-side**
  - Optimum heel angle (10°-12°)
  - Some boats like more or less heel.
- **Neutral rudder** (don’t use as brake)
- **Tests:**
  - Look at wake. Big stern wake = too much wt. aft
  - Tiller feel: 5° weather helm
- **Sail trim is ineffective with bad boat trim.**

#3: Trim the Sails

- That’s what we’ll talk about now.

Sail Parts

Good stuff happens when they work together.
Everyone knows

- Sails use wind to propel sailboats
- Sails’ driving force/power, is called “lift”.
  - Lift good, makes boat go.
- Sails also have “drag”.
  - Drag bad, slows boat.
- Force needed to accelerate & (due to drag) to maintain speed.

Less recognized

- Boats sail in their apparent wind, not true wind.
- Air is a fluid; same physics apply as for water.
- No Lift without Drag; more Lift — more Drag
  - Two kinds of Drag
    - Parasitic — air “friction”; increases exponentially with wind speed
    - Induced — byproduct of lift, increases with lift
- Want high L/D Ratios: more drive, less drag.
- Front 25% of sail’s lee side does most of “good stuff”
- Sails take energy from wind; convert to boat speed

Sails are Wings

Wings depend on

Air Flow

No flow = no work

Types of Flow

Air Flow

Three kinds of air flow over sails:

1. **Laminar attached** is ideal
   - The longer flow stays attached the better
   - Hard to achieve or keep
2. **Turbulent detached** is worst
   - Much drag, little lift
3. **Turbulent attached** a compromise
   - Easier to achieve, keep than laminar

Lee side of the sail does the most work and where flow detaches most easily.
**Rule**

- You can’t **force** flow to obey.
- It follows its own whims.
- You can only **coax** it to stay laminar & attached.

**Sail Trim Guides**

**Telltales** indicate flow
- Streaming aft: good
- Lifting: verge of stall
- Hanging: stalled
- Forward: reverse flow

**Draft stripes** help show sail shape

Trim Toward the Telltale: Any telltale not streaming is telling you to move that part of the sail toward it.

---

**See the Flow, be the Flow**

- Use **draft stripes** to see shape
- **Telltale**s to see flow
- **Picture** how the wind flowing over sail
- Where flow detaches, move that part toward the wind.

---

**Radical Idea!**

Sails work best as **Energy Converters**

- Take energy from wind; convert to boat speed.
  - $E_w \rightarrow v_b$

---

**Boring Physics Stuff**

- More Physics Stuff
  - $F_a = -F_b$ (For every action, there is an equal & opposite reaction.)
  - $F = ma$ (Force = mass * acceleration)
    - also $a = m/F$
  - $V = at$ (Velocity = acceleration * time)
    - $V = (m/F) \times t = mt/F$
  - $E_k = mv^2/2$ (Energy = mass * velocity$^2$/2)
    - $v^2 = 2E/m, v = \sqrt{(2E/m)}$
    - $Fs = mv^2/2$ (Force x displacement = Energy)
  - $\Sigma E = 0$ (Energy is conserved; just changes form.)
  - $P = E/t = mv^2/2t$ (Power = Energy/time)

Now added back on request

Skip it if you want
Three Models

Three ways to look at how a boat sails:

• **Forces**
• **Motion**, momentum, etc.
• **Energy**, Power, Work

Each useful for different aspects

<table>
<thead>
<tr>
<th>Measurement Units</th>
<th>Vector Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English:</strong></td>
<td>Basic physics concept</td>
</tr>
<tr>
<td>• <strong>Force:</strong> Pounds-force (lbf) = 32 lb. weight</td>
<td>To add, go head-to-tail; result is tail-to-head</td>
</tr>
<tr>
<td>• <strong>Distance:</strong> Feet (ft), Nautical miles (nmi)</td>
<td></td>
</tr>
<tr>
<td>• <strong>Speed:</strong> Feet per second (fps), Knots (kn)</td>
<td>• Combine magnitude and direction</td>
</tr>
<tr>
<td>• <strong>Kinetic Energy:</strong> Foot-pounds per second (fps)</td>
<td>• Can be added and subtracted</td>
</tr>
<tr>
<td>• <strong>Power:</strong> Foot-pounds/sec (fp/s), Horsepower (hp)</td>
<td>• Used to solve physics problems</td>
</tr>
<tr>
<td><strong>International:</strong></td>
<td></td>
</tr>
<tr>
<td>• <strong>Force:</strong> Newton (N) = 0.22 lbf</td>
<td></td>
</tr>
<tr>
<td>• <strong>Distance:</strong> Kilometers (km) = 0.54 nmi</td>
<td></td>
</tr>
<tr>
<td>• <strong>Speed:</strong> kilometers per second (kms) = 0.54 kn</td>
<td></td>
</tr>
<tr>
<td>• <strong>Kinetic Energy:</strong> Joule (J) =</td>
<td></td>
</tr>
<tr>
<td>• <strong>Power:</strong> Watts (w) = 0.74 fp/s) = 0.0013 hp</td>
<td></td>
</tr>
</tbody>
</table>

**Vector Math**

• To add vectors, place tail of one at head of another.
  – You can do this in a chain of many vectors.
  – Resultant goes from tail of the first to head of the last.
• To subtract a vector, reverse its direction.

**Three Models**

• Wind pushes/pulls on sails
• Sails push/pull back on wind
• Push/pull of wind translates to push/pull on boat

**Momentum Model**

• Momentum of wind changed when encounters boat and sails
• Change in momentum transferred to boat
**Kinetic Energy Model**

Sails take energy from wind by
- **slowing** it &
- **turning** (bending) it

Wind leaves sails with
- Less energy,
- “Lifted” &
- Turbulent

![Kinetic Energy Model Diagram]

**Wind Physics**

- **Air is a fluid!** (like water)

\[ P = \frac{1}{2} \rho A v^3 \]
- \( P \) = power; \( A \) = sail area; \( \rho \) = air density; \( v \) = wind velocity

- Power increases w/ **cube** of wind speed.
  - Velocity is a component of air mass hitting sails.

**Basic Wind & Air**

**What is wind?**
- A mass of air in motion
- Motion of the mass gives it energy

**What is air?**
- A fluid, containing gases:
  - 21% \( O_2 \)
  - 78% \( N_2 \)
  - 0.04% \( CO_2 \)
  - 1% Argon
  - <0.1% other
  - 7% \( H_2O \) (water vapor)
- Each molecule in random motion relative to others in mass

**What is air’s mass & weight?**
- Air weighs ~ 0.0807 lb/ft\(^3\) @ standard pressure & temperature
- Mass of 1 ft\(^3\) = 0.0025 slugs = 3.59 Newtons
- A slug weighs ~ 32.17 lbs.
- Changes with weather (high pressure vs. low)
- Declines with temp
  - ~3% for every +10°F
- Declines with altitude
  - 5% less @ 5280'
  - 17% less @ 9000'
- Declines with humidity; wetter air less dense

**Misconception**

Some sailors say “more pressure” to mean higher wind speed. **Wrong!**
- Faster-moving air actually has **less** pressure (Bernoulli’s principle)
- That’s why lee side of sails (faster flow) does more work.

**Wind Power**

Compared to power in 1 knot of wind speed, \( P_1 \)
- 4 knots = 64*\( P_1 \)
- 8 knots = 512*\( P_1 \)
- 16 knots = 4096*\( P_1 \)

![Wind Power Graph]

**Sail Mechanics**

- To take energy from wind, sails need optimum flow.
- More **laminar** flow, more energy taken
- Longer **attached** flow, more energy taken
### Get out and push?
- A 2400 lb. boat, moving at 4.5 knots has
  - ~6,750 joules of kinetic energy
  - About the same as to raise the boat two feet
- To reach 4.5 knots from 0 in 30 seconds
  - Took an average of ~225 watts of power.
- Required driving force was
  - Effective ~84 lbs. more than drag (air+water)
  - At 59% efficiency, ~142 lbs.

### Sail Mechanics
- To take energy from wind, sails need optimum flow.
- More laminar, more taken
- Longer attached, more taken

### Sail Efficiency
**Measure:** Coefficient of Lift, $c_L$
- Soft (fabric) sails, $c_L \approx 1.5 - 2.0$
- AC72 wings, $c_L \approx 2.0 - 2.5$
- AC72 hard sails $\approx 25\% - 33\%$ more efficient than soft sails.

- **Max efficiency $\approx 59\%$**
  - In "perfect" trim.

### Upwash
- Wind bends **before** it meets sails.
- It "anticipates" resistance

### Boundary Layer
If you could see flow in minute detail, you’d see that
- Flow is slowest nearest the surface it flows across.
  - At the boundary between surface & fluid, flow is zero; it’s "stuck" to the surface.
  - This is the cause of parasitic drag.
- Flow is faster as it gets further from the boundary layer

### Lift vs. Drag
- One sail behaves like airplane wing with flaps.
- Two sails behave like wing with flaps and slats.
**Which is faster?**

A bag?  Or a sail rocket?

Make the physics work for you

---

**Climbing under the hood**

To get into the guts of how sails work, see [http://syr.stanford.edu/SAILFLOW.HTM](http://syr.stanford.edu/SAILFLOW.HTM)

- e.g., "Forces acting on the sail are determined by integrating the pressure distribution over the sail area."

"Physics of Sailing" is a traditionally technical work.

- [http://grizzly.colorado.edu/~rmw/files/papers/PhysicsofSailing.pdf](http://grizzly.colorado.edu/~rmw/files/papers/PhysicsofSailing.pdf)

"How do sails work?" by Paul Botajav


"Aerohydrodynamics of Sailing" by C.A. Marchaj; the classic

- [Google](http://www.google.com) is a great resource!

---

**Rig Tune Question**

- **Q:** Where can I get a tuning guide for my boat?
- **A:** Try Class association, manufacturer, sail maker or professional rigger
- If none of those work:
  - Mast straight & vertical
  - Set forestay length so yields 5° weather helm upwind.
    - Shorter forestay → less weather helm
    - Longer forestay → more weather helm
  - Set shroud tension so mast vertical & lowers tighter than uppers.
    - Allows tip to fall of & depower in gusts

---

**Draft Stripe Question**

**Q:** Are draft stripes important? How many are needed? Where?

**A:** Yes, unless you’re highly skilled at reading sail shapes. Draft stripes make it easy to see depth, draft and twist on main & jib.

- I recommend three – at ¼, ½ & ¾ up the sail.
- Don’t follow seams but use same points on luff and leach.

---

**Questions?**

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**Optimum Trim**

- **Compromises:**
  - Lift vs. Drag
  - Driving force vs. heeling force
  - Power vs. speed
- **Conditions:** Speed & direction of wind, Water surface (flat, choppy, big waves), Current
- **Requirements:** Where want to go (upwind, downwind, reach), Risk, How fast (ASAP?), Comfort (hiking)

**Trim Needs Always Changing**

- Requirements change frequently
- Conditions change constantly
- Optimal trim changes second-to-second

**Trade-offs**

<table>
<thead>
<tr>
<th>Power (for)</th>
<th>Efficiency (for)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Acceleration</td>
<td>• Speed</td>
</tr>
<tr>
<td>• Waves/chop</td>
<td>• VMG</td>
</tr>
</tbody>
</table>

With:
- • Deep sails
- • Draft forward
- • Minimal twist

With:
- • Flat sails
- • Draft aft
- • More twist

**5 Dimensions of Sail Trim**

5 Trim Dimensions

1. **Attack Angle**
2. **Depth**
3. **Draft position**
4. **Twist**
5. **Slot & Balance**

The first four apply to all sails. Slot & balance apply to combinations of two or more sails.

**#1: Attack Angle**

Angle of apparent wind to sail’s chord line

- **Bigger angle**
  - = Tight sheet
  - ↑ lift (to a point)
  - ↑ risk of stall
- **Smaller angle**
  - = Eased Sheet
  - ↓ lift
  - ↓ stall risk
#1a: Attack Angle +
- Bigger angle:
  - Higher L/D (to a point)
  - More stall risk
- Stall is bad; ask pilots:
  - Flow detached & turbulent.
  - Angle = 90° → stall.

When in doubt, ease the sheet out.

#1b: Attack Angle ++
- Dimension changed most often.
- Trim sail to apparent wind – which (if boat moving forward) is forward of true wind.
- Stall bad: Flow detached and turbulent.
  - Attack angle = 90° → stall.

#2: Depth
Ratio of depth to chord length
- Deeper = More
  - Power
  - Drag
  - Stall risk
- Go Deeper = Ease
  - Sheet
  - Outhaul
  - Backstay
- Go Flatter = Tighten (harden up) sheet, outhaul, backstay

#3: Draft Position
Location of max depth fore/aft re: chord length
- Forward =
  - Round entry, straight leech
  - Forgiving, wide groove
  - Less efficient
- Control by cunningham or halyard
  - Tighter for forward
  - Looser for aft
- Draft moves aft with ↑ wind
  - Leach hooks, acts as a brake

Draft aft a problem for old sails

#3a: About Draft
Draft Forward:
- More forgiving,
- Less prone to stalling
  - Wider “groove”
- More lift → more acceleration

Draft Aft:
- More efficient
- More prone to stall
  - Narrower groove
- Less drag → higher speed

> 50% usually bad

#4: Twist
Less attack angle w/ height
- More twist =
  - Less power up top
- Add twist in
  - Heavy wind
  - Very light wind

Twist takes it vertical
#4a: Twist +

**Important** because

- Apparent Wind high = **stronger & lifted** re: wind low.
- Flow separation **begins at top** of sail and spreads down

---

#5: Slot & Balance

**Slot:** Opening between jib/genoa & main
- **Synergy** makes both sails more effective

**Balance:**
- Jib pulls bow down
- Main pulls stern down, bow up

---

**Sail trim is about:**

1. **Attack Angle**
2. **Depth**
3. **Draft position**
4. **Twist**
5. **Slot & balance**

See the sails in all their dimensions.

---

**Questions?**

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---

**Twist Question**

- **Q:** Why is wind stronger aloft than on surface?
- **A:** Because there’s less resistance up there. When wind blows across any surface, it feels skin friction drag. highest near the boundary layer. See [https://en.wikipedia.org/wiki/Skin_friction_drag](https://en.wikipedia.org/wiki/Skin_friction_drag).
- This effect is more noticeable in light air.

---

**Mainsail Question**

- **Q:** What about square-headed mains?
- **A:** With more area up top, maybe add a bit more twist in higher winds.
# Sail Controls

What the strings do & how they optimize trim
(Soft sails only; hard sails have more)

## Sail Trim Controls

- **Mainsail** (6)
  1. Mainsheet
  2. Traveler
  3. Outhaul
  4. Cunningham, Downhaul, Halyard
  5. Boom Vang
  6. Backstay, mast ram, etc.

- **Jib/Genoa** (4-5)
  1. Jib sheet
  2. Jib sheet leads
  3. Cunningham/Halyard
  4. Backstay
  5. Barber-hauler? (Lead inboard/outboard)

- **Spinnaker** (3-4)
  1. Sheet
  2. Twing, tweaker?
  3. Pole height
  4. Pole angle (fore/aft)

## Mainsail Controls

- **Mainsheet** affects
  - Attack angle
    - In = ↑ attack angle
    - Out = ↓ attack angle
  - Depth
    - In = ↓ depth
    - Out = ↑ depth
  - Twist
    - In = ↓ twist
    - Out = ↑ twist
  - Slot
    - In = opens slot
    - Out = closes slot

- **Traveler** affects
  - Attack angle
    - Up = ↑ attack angle
    - Down = ↓ attack angle
  - Slot
    - Up = Open
    - Down = Closed

## Mainsail Controls +

- **Outhaul** affects
  - Depth (lower 1/3)
    - Aft = ↓ depth
    - Fwd = ↑ depth

- **Cunningham** affects
  - Draft position
    - Tight = Draft fwd
    - Loose = Draft aft

## Boom vang affects

- Depth
  - Tight = ↓ depth
  - Loose = ↑ depth

- Twist
  - Tight = ↓ twist
  - Loose = ↑ twist

## Backstay

1. When tightened, bends mast; depth pulled out of mainsail.
   - Leach opens & twist increases because head gets closer to clew.

2. Tightens forestay; depth pulled out of jib.

Other boats may have different ways to get the same effects.

---

Mainsheet affects 4 factors, not all how you’d want.

- Pulls boom **down** as well as in & lets boom **rise** as it goes out.
- Say, you ease the sheet in a puff:
  - Attack angle ↓ & Twist ↑ (good) but
  - Depth ↑ & Slot closed (bad)
- Other controls (backstay, traveler) trim for puff with fewer bad effects

---

Black is backstay “off”; red is backstay on.
### Traveler & Vang

**Traveler**
- **Keelboat:** Adjusts attack angle
- **Dinghy:** Adjusts angle, depth, twist

**Vang**
- Adjusts **depth** & **twist**
- Limits boom lift

### Cunningham & Outhaul

**Cunningham**
- Adjusts draft position
- Tighter pulls draft forward

**Outhaul**
- Adjusts (lower) **depth**
- Tighter flattens foot

### Jib Controls

**Jib sheet** affects
- **Attack angle**
  - In = ↑ attack angle
  - Out = ↓ attack angle
- **Depth**
  - In = ↓ depth
  - Out = ↑ depth

**Sheet lead** affects
- **Twist**
  - Fore = ↓ twist
  - Aft = ↑ twist

### Cunningham/Halyard
- **Draft position**
  - Tight = Draft forward
  - Loose = Draft aft

**Backstay** affects
- **Depth** (vertical)
  - Hard = ↓ depth
  - Loose = ↑ depth

### Jib Sheet Tension

- **Attack angle**
  - In = ↑ attack angle
  - Out = ↓ attack angle

- **Depth**
  - In = ↓ depth
  - Out = ↑ depth

- **Slot**
  - In = Closes slot
  - Out = Opens slot

### Sheet Lead

- **Twist**
  - Fore = ↓ twist
  - Aft = ↑ twist

Forward lead pulls **down** on leach
### Jib Halyard/Cunningham

- Halyard pulls up on head; cunningham pulls down on tack.

- **Draft position**
  - **Tighter**: Draft forward
  - **Looser**: Draft aft

A cunningham is easier to adjust than a halyard,

### Barber-hauler

Adjusts lead in/outboard & affects

- **Attack angle**
  - In = ↑ angle
  - Out = ↓ angle

- Used for “power reaching”
- Complicated
- Most of our boats don’t have barber- haulers

### Questions?

**Mainsail Question**

**Q**: What’s the big advantage of playing the traveler in puffy conditions?

**A**: It allows keeping depth & twist trim the same and don’t have to recheck the sail.
  - Just look at traveler position.

**Jib Question**

**Q**: How does sheet lead affect twist?

**A**: See diagram

- Moving the lead forward **reduces twist** by putting more downward tension on leach.
- Moving the lead aft **increases twist** by putting on less downward tension.

---

**Mainsail Question**

**Q**: What is vang sheeting and why use it?

**A**: In this technique, the boom vang is set hard for minimum depth. Easing the sheet thus affects only the attack angle.

- Used in puffy air when needed attack angle adjustments exceed the traveler’s limits. See [http://www.sailingbreezes.com/sailing_breezes_current/articles/Aug00/dell0800.htm](http://www.sailingbreezes.com/sailing_breezes_current/articles/Aug00/dell0800.htm).
- Vang sheeting is also used temporarily (at leeward marks) on boats with long main sheets. The vang gets the main under control until the sheet can be trimmed.
Leach Question

**Q:** How much should I tighten the leach cord?

**A:** Just enough to take out flutter; any more hooks the leach and acts as brake.

- Stretched-out sails need leach cords; the leach is no longer a straight line.
- Flutter is bad because it makes turbulence & detaches flow.

**Opinion:** Leach flutter is a signal that the sail needs re-cutting or replacing.

---

Spinnaker Trim

On many boats, a spinnaker more than doubles sail area

---

The Finicky Spinnaker

- Most powerful sail on the boat; makes boat go fast downwind.
- Can be the most troublesome and dangerous. If not treated right, it can hurt you.

- Broach
- Pitchpole

Don't pitchpole! Dangerous!

---

Limited Control

- Attached to boat at only 3 points:
  - Head, tack & clew
  - All are loose; sail is free to move around.

- No luff attachment.
- Supported only by own lift

---

Spinnaker Strings

- Spinnaker’s luff isn’t fixed to mast or stay.
- Free to go where flow takes it.

Spin Controls Lists

<table>
<thead>
<tr>
<th>Symmetrical:</th>
<th>Asymmetrical:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pole Height (by topping lift)</td>
<td>1) Tack line, controls height &amp; angle</td>
</tr>
<tr>
<td>2) Pole Angle (by guy)</td>
<td>2) Sheet</td>
</tr>
<tr>
<td>3) Sheet</td>
<td>3) Sheet Twing</td>
</tr>
<tr>
<td>4) Foreguy/Guy Twing</td>
<td>5) Sheet Twing</td>
</tr>
</tbody>
</table>
**Spinnaker Flow**

**Important!**

- Flow goes turbulent & detaches before it reaches leach.
- Try to retain as much flow as possible.

**Spin Controls**

**Pole Height** affects
- Depth (vertical), shape of luff
  - Up = ↑ depth
  - Down = ↓ depth
- Draft position
  - Up = Draft aft
  - Down = Draft forward

**Pole Angle** affects
- Angle of attack of luff; best 90° to apparent wind
  - 0° attack angle of sail

**Sheet** affects
- Depth (horizontal)
- Attack angle

**Foreguy/Guy Twing** limits
- Pole height; keeps pole from skyning in puff

**Sheet Twing** affects
- Lead position, twist
- Area exposed; "choke" chute in heavy air

---

**Pole Height**

**Most critical setting!**

Works like cunningham; pulls draft forward

- **Pole too low:**
  - Center of chute to weather of forestay
  - Sail unstable; collapses easily; needs too much sheet tension.
- **Pole too high:**
  - Luffs in top 1/3
  - Sail unstable, rolls
- **Just right:** Center seam vertical, curl in center panel
  - Tack often lower than clew, never above clew.
  - If adjustable mast attachment, keep pole horizontal for max projected area.

With asymmetrics, tack use pendant?

---

**Pole Angle**

- **90° to apparent wind**
  - Best attack angle
  - Optimum projected area
  - Never touching forestay; risk to pole & rig
- **Too forward**
  - Lose exposed area
  - Too little attached flow
- **Too aft**
  - Causes over-sheeting
  - Prone to stall
- **Test: Luff is vertical**
  - Luff points toward bow, ease pole forward
  - Luff points to windward, trim pole back

---

**DDW (Dead Down Wind)**

- In DDW mode, most of sail is stalled.
- Biggest attack angle possible.
- Flow not attached.
- Spinnaker acts like a bag, not a wing.

Tip: Sail 5° - 10° higher
## Sheet Tension

### Just right:
- Sail stays full; luff curls occasionally

### Too loose:
- Sail collapses

### Too tight:
- Sail stalls
- Excess heel
- Risk of broach

## Sheet Guide

- Ease & trim constantly
- Ease until curls, then trim slightly
- When overpowered, ease until boat on lines.

## Gusts & Lulls

Play the **sheet** constantly.

- **Ease for gusts**
  - Keeps boat on lines
  - Prevents broaching

- **Trim in for lulls**
  - If lull persists, raise pole

## Other Strings

### Foreguy &/or Guy Twing
- Limits pole height; avoids powering up chute in gust
- Foreguy more effective; twing partly effective

### Sheet Twing
- Changes lead position of sheet (like barber-hauler on jib)
- Use in heavy air to choke & stabilize chute (reduce rolling)

## Discussion?

J24s, pic from North Sails’ site  
Look at center seams & curl locations

## Communication

**Trimmer/Driver Communication critical:**

- When trimmer feels more pull (AKA, “pressure”) on sheet, tell driver so can bear off

- When driver heads up for more speed, tell trimmer so trim can be adjusted.
### Heavy Air Running Tip

**Pull in twing** on sheet to

- **Reduce area** (power)
- **Stabilize chute**
- **Reduce rolling**

### Questions?

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### Running Question

**Q:** What is the advantage of sailing a bit higher than dead downwind (DDW)?

**A:** Two advantages:
- Increase apparent wind
- Flow over lee side of sails

- The extra distance sailed for 10° higher vs. DDW is only 1.5%, but speed can be increased 10%-20%.
- The lighter the wind, the higher to sail.

### Spinnaker Question

- **Q:** Is it wrong to have the head horizontal?
  - **A:** No. It's more common on masthead rigs because the main isn't blocking flow into the head.

### Spinnaker Question

- **Q:** Can wind enter the chute at the leach?
  - **A:** It's a definition thing; the place where the wind enters is called the luff. On a (symmetric) chute, it changes with each jibe.
  - If flow reverses and enters where there's no pole to restrain the chute, it's trouble.

### Pole Angle Question

- **Q:** Should pole be parallel to boom?
  - **A:** A starting point, but
    - Mains limited (by shrouds) as to how far out.
    - Sometimes we want the main over-trimmed to direct air into chute.
### Backstay Question

**Q:** Should backstay be off downwind?

**A:** Yes.
- The mast should be allowed (see picture) to move forward.
- This moves the center of effort forward & helps steering.

### Balance Sails

- **Balance** main and jib for straight line speed – low weather helm.
- To bear off, ease main, w/ jib tight.
- To turn up, harden mainsheet.

### Sail Balance +

- Balance sail & boat trim for slight windward helm
  - ~ 5° tiller above centerline
  - Gives helm “active feel”
- Too much → boat turns up & auto-tacks
- Too little → boat turns down

### Light to Moderate Wind

6-15 knots, Beaufort 2-4

- **Power up to accelerate**
  - Small attack angle
  - Deep sails
  - Draft forward
  - Minimal twist
- **At max speed, trim for efficiency & VMG**
  - Increase attack angle a bit
  - Flatten sails a bit
  - Move draft aft a bit
  - Add a little twist

### Heavy Air

- 15-30 knots, Beaufort 5-7, gusty
- Keep boat on her lines, avoid over-heel & auto-tacks
- **Power down**
  - Reduce attack angle (sheet/travel out)
  - Flatten sails
    - Backstay on
    - Vang sheeting?
  - More twist to reduce heel
  - Draft forward
Super-light Air

- <4 knots, Beaufort 0-1
- You want power, but flow not attached enough to generate it.
- Trim as for heavy air
  - Flat sails
  - Draft forward
  - More twist (Wind stronger aloft & lifted)

In doubt? Feel slow?

- Ease
  - Sheet (more depth, less attack angle)
  - Vang (more depth & twist)
  - Outhaul (more depth)
- Tighten
  - Cunningham (draft forward)
- Lower traveler (less attack angle)

Questions?

- Super-light Air
  - <4 knots, Beaufort 0-1
  - You want power, but flow not attached enough to generate it.
  - Trim as for heavy air
    - Flat sails
    - Draft forward
    - More twist (Wind stronger aloft & lifted)

Questions?

- Pitchpole Question
  - Q: What causes and how do you avoid pitchpoling?
  - A: Risk increases with wind and waves. The bow can run under the back of a wave & submerge, lifting the stern.
    - Move weight aft to keep bow up.
    - Take waves at an angle to allow the bow to climb them.

Conditions Question

- Q: Why trim in super-light air the same as for heavy air?
- A: It’s counter-intuitive because, in heavy air, you have too much power and, in super-light, not enough power. But
  - Weak wind needs flat sails to stay attached
  - Weak wind is stronger aloft so needs more twist.

Final Thoughts

- Easy Adjustments
- Reproducible settings
- One adjustment at a time
- Things to avoid
## Easy Adjustments

All controls should be easily & quickly adjustable.

- Set up so **handy** for crew responsible. (If too hard, it may not get done.)
- Ensure lines can run freely.

## Reproducible Settings

- **Mark lines** for standard (base) settings.
- **Replace guessing:** when marks line up, you’re in the ballpark.
- **Adjust** from marks for conditions and requirements.

## One Adjustment at a Time

1. **Patience:** Allow time to take effect
   - How much depends on boat
   - Heavier boat → more time
2. **Gauge effect** before next adjustment
3. Make **next** adjustment (Go thru trim loop.)

## Avoid

- **Telltales hanging limp**
  – Sail stalled
- **Telltales streaming forward** (except on run)
  – Reversed flow
- **Leach hooked** to windward
  – Acts as brake
- **Sails in water** (slow)

## Conditions Question

- **Q:** Why trim in super-light air the same as for heavy air?

  - **A:** It’s counter-intuitive because, in heavy air, you have too much power and, in super-light, not enough power. But
    - Weak wind needs flat sails to stay attached
    - Weak wind is stronger aloft so needs more twist.

## Questions?

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**Miscellaneous**

**Conditions**

**Wind**
- **Strength**
  - Speed
  - Super-lite
  - Light
  - Moderate
  - Heavy
  - Gear-breaking
- **Variability**
  - Steady
  - Puffy
- **Direction**
  - Steady, persistent or progressive
  - Rapidly oscillating

**Water**
- **Surface** (waves)
  - Flat
  - Light chop
  - Heavy chop (steep)
  - Small rollers (<3’)
  - Medium rollers (3-5’)
  - Big rollers (>5’)
- **Current**
  - None
  - Fair
  - Foul

**Requirements**

- **To weather mark**, close-hauled
  - **Standard** mode, best VMG to windward
  - **Footing** mode, emphasizes speed
  - **Climbing** mode, emphasizes pointing

- **To leeward mark** (run)
  - Best VMG

**Chute Controls: Big Boat**

- Adds reaching strut + lazy sheets & lazy guys

We don’t see many reaching struts around here; they take too much time for short legs. Their function is to keep the afterguy off the shrouds.

We also don’t see many lazy sheets & lazy guys. They’re needed when forces on loaded lines are too high.

**If you get nothing else:**

**Go with Flow!**

**Thank you for helping celebrate my 78th birthday**