

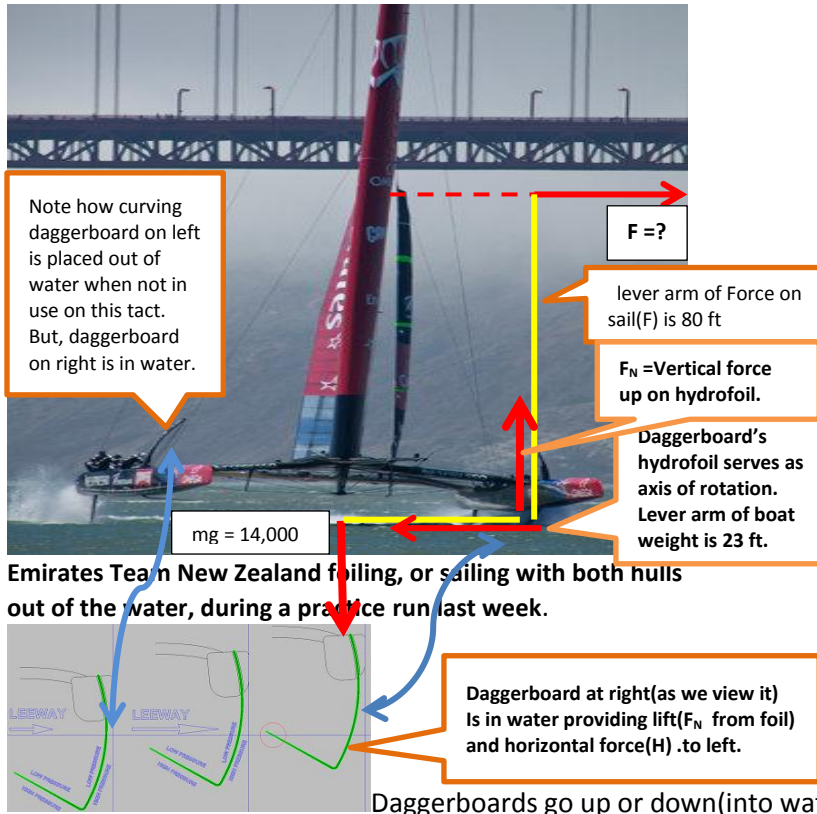
# STATIC & ROTATIONAL EQUILIBRIUM Unit 15 Dr J Cise

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SPECIAL REPORT: LOUIS VUITTON CUP

## In the America's Cup, Yachts That Can Sail on Air

SAN FRANCISCO — Max Sirena, the Italian skipper of Luna Rossa Challenge, was standing inside a converted airplane hangar. Watching his shore crew at work on wing sails and gleaming hulls, he wondered if it was still right to define the focus of all this expert attention as a boat.



Emirates Team New Zealand foiling, or sailing with both hulls out of the water, during a practice run last week.

**INTRODUCTION:** This Americas Cup hydrofoil sailboat is moving at 46 mph. It is out of the water due to small hydrofoil forces up on the two rear rudders and a major vertical force ( $F_N$ ) up on right daggerboard's horizontal shaped hydrofoil (under water in picture at left).

**QUESTIONS:** Lever arms & forces are given in graphic at left. Forces  $F_N$  &  $H$  are exerted on hydrofoil's L shaped base (taken as axis of rotation) under water at base of daggerboard.  
 (a) Using condition for rotational equilibrium  $\Sigma \tau = 0$ , find force of wind on sail  $F$ ?  
 (b) Using condition for static equilibrium in vertical direction  $\Sigma F_y = 0$ , find vertical force  $F_N$  on hydrofoil fin under water? (c) Using condition for static equilibrium in horizontal direction  $\Sigma F_x = 0$ , find horizontal force  $H$  (to the left) on submerged daggerboard due to water it is passing through.

**ANSWERS:** (a) ~ 4025 lb., (b) ~14,000 lb. (c) ~ 4025 lb.

**HINT:** Carefully set up your three equations to solve for the three unknowns.

Daggerboards go up or down (into water)

“It’s really more a machine,” he said recently. For decades, Sunday sailors could identify with America’s Cup yachts, with their monohull designs, soft sails, narrow decks and relatively benign speeds. But the 162-year-old competition, whose preliminaries begin this weekend with the start of the Louis Vuitton Cup, has now cut the cord with the yacht-club experience. The 72-foot, high-performance catamarans being used this year are capable of sailing more than 40 knots, or **46 miles per hour**. Sailors must now wear protective armor and helmets, and, since the [death of the Artemis Racing crew member](#) Andrew Simpson in May, they are also required to wear portable air canisters in case they are trapped underwater. But what is particularly eye-catching about this class of big boats — machines, if you agree with Sirena — is their spectacular capacity to foil. **Foil is the nautical vernacular for hydrofoil, and it means, in this case, that these catamarans are able to sail — at least downwind — (((with both hulls out of the water)))**. Live or on a screen, it looks like a special effect: the raptorlike yachts levitating as all that carbon fiber and sail area and manpower are supported by only the slender rudders and dagger boards still in the ocean. “It’s the most amazing sensation when you look down and there’s **no part of the boat in the water, just the two foils on the leeward hull and the rudder on the windward one**,” said Dean Barker, the skipper of [Emirates Team New Zealand](#). “Just the sheer acceleration of the boat when it breaks clear of the water is quite remarkable.” Iain Murray, the veteran sailor who is regatta director for the America’s Cup, took a ride on Oracle Team USA’s AC72 this year and was struck by the shift in mood once the yacht began to foil. “Well, look, the ride is incredibly smooth,” Murray said. “Most of my time going fast has been in boats bouncing all over the ocean. Whether it be skiffs jumping out of the waves or whatever, it’s a pretty rough ride. These things are not like that. They are very smooth, very progressed, very efficient and very quiet. You know you’re going plenty fast, but there’s no huge sensation of danger.”