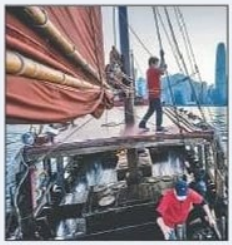

The traditional Chinese junk boat, which sails with three masts, requires good navigational skills.
AFP

TIMELESS PRINCIPLES AND WIND OF CHANGE

I have described how sea vessels can maintain stability and gain forward motion by propellers. But before steam and diesel power were applied to ships, most of them gained forward motion by catching wind from sails.

Wind power is a convenient and economical resource to push sea vessels forward to help them to reach their destination, but wind does not always blow in the direction that aligns with the intended travel path.

Modern sail boats are equipped with auxiliary power, using conventional propellers, to gain forward movement in adverse wind or no wind, but in the ancient days such devices were not available.

Ingenious nautical engineers of those days invented sailing ships with multi-masts. By adjusting the direction the sails face, they were able to direct wind to the main sail to propel the ship ahead in the desired direction.

Sometimes, they have to steer the ship to move in a zig-zag direction to catch the wind, but all in all, a generally forward direction can be achieved.

A typical example is the Chinese junk, which has three masts. The main mast in the middle provides support for the main sails, which catch the wind to propel the junk in the forward direction. The two other masts, in front and behind, can be steered to catch wind in whatever direction and direct the wind force toward the main sail to push the junk ahead.

Good navigation skills are needed to guide the sails to gain forward movement, but again the progress may not always be in a straight line, but in a series of zig-zag lines. As junks have a flat bottom, to ensure stability, the navigation speed of a junk is limited to a few knots, and in times of high wind or typhoon they cannot sail.

A modern racing boat has a relatively tall and large sail to provide a bigger surface area to convert the wind pressure to pushing power to move the boat forward at relatively high speed, often up to high tens of knots. Stability is maintained by a deep fin attached to the hull, to provide reaction forces to allow the boat to float on the water surface without capsizing.

The principle of a racing sailing boat follows that of an airplane, and we can regard a sailing boat as an airplane turned 90 degrees to the side. One wing is the sail that we can see on top of the boat, and the other wing is the fin at the bottom of the boat, submerged in water and out of sight.

Differential pressure on either side of the sail provides a lifting force like that allowing an airplane to fly, but in a racing boat, this pressure provides the wind force acting on the sail to propel the boat forward with a large force to give it the acceleration and speed required to get ahead in competition. The fin provides the counteracting force in water to keep the boat on even keel, even at speed and at fast turns.

Note that the submerged fin is much smaller than the sail, but this is because the density of water is much more than that of air and the same reaction force can be gained from a smaller surface area.

The sail can be steered swiftly to gain maximum wind pressure and direction control is helped by a large rudder at the rear.

Engineers apply basic principles of physics to serve our everyday needs, including land, sea and air transport. The applications may evolve with age, but these principles do not change with time.

Veteran engineer Edmund Leung Kwong-ho casts an expert eye over Hong Kong's iconic infrastructure