Stability II: Gravity vs. buoyancy centers

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FISH SAFE

Theresa Dolloff graphic

As we saw in the first installment in this series on stability (CFN August 2003, page 23A), the center of gravity is a downward force that appears to be exerted from a single point or center. Now, let's look at the center of buoyancy and how it relates to the center of gravity in various situations.

Any vessel or container that is floating in a liquid has a center of buoyancy as well as a center of gravity. While the center of gravity is the point through which gravity seems to push *down,* the center of buoyancy is the point through which buoyancy or lift seems to push *up.*

The center of buoyancy is the center of the volume of the vessel that is under the water. The center of buoyancy *moves* based on how much of the vessel is under water.

That contrasts to the center of gravity, which moves when the load is raised, lowered, or moved to the side as we learned from the experiment in the August article.

It is the relative position of these two centers that determines whether a vessel will capsize.

FISH SAFE:

- Avoid superstructures that raise the center of gravity.
- Use bins to keep the load from shifting when stowing fish in the hold.
- Reduce the risk of flooding and therefore capsize by making sure your hull and through-hull fittings are in good shape.

Let's experiment

You can experiment with the center of buoyancy by finding a clear pint-size container, such as one from a deli counter. Next, get some dirt, sand, or even brown sugar, anything that is moist and can be pressed into different shapes.

Fill a sink or large container with water and float the empty pint-size container in it. It will float high because it is light and easily buoyed up by the water.

The center of gravity will be at the center of the container, but the center of buoyancy will be in the center of the tiny portion of the container that is under water.

The container will float exactly upright because the center of buoyancy is *directly under the center of gravity* (see Fig.1).

Now, evenly fill the container half-full with the moist dirt, pack it down a bit, and then float it. You'll see that the container displaces more water because it is heavier. The center of gravity is lower and the center of buoyancy is still directly below the center of gravity.

Therefore, the container will continue to float upright (see Fig. 2). This set-up more nearly approximates how a loaded boat works.

Moving loads

Now, move some of the dirt to one side and pat it into a new shape (see Fig. 3) and float the container again.

What's the difference?

There is a shift in the relationship between the centers of gravity and buoyancy. The center of buoyancy has moved in the direction of the dirt and is no longer directly under the center of gravity. The center of buoyancy is pushing up from the dirt side of the container and is trying to keep the container afloat. This resembles what happens when water or freely moving fish in the hold is able to move from side to side.

Next, try moving more of the dirt to one side. At some point, the container will likely capsize (see Fig. 4).

Now that we have a clear picture of how the centers of gravity and buoyancy interact, we'll move on next time to a discussion of their connection to heeling and righting moments.

The aim will continue to be achieving a better understanding of how to avoid instability conditions that can lead to capsize. ■

Fig. 1

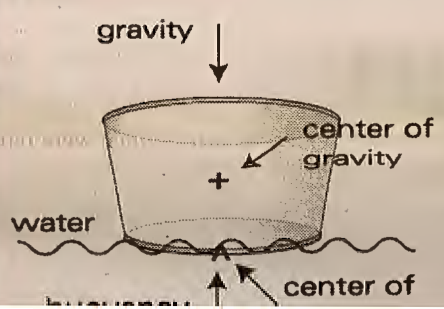


Fig. 2

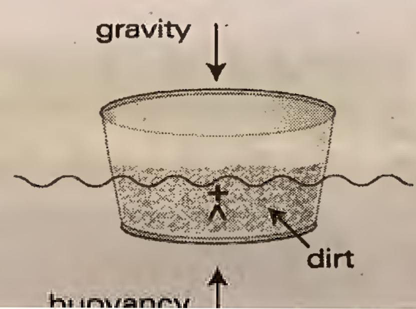


Fig. 3

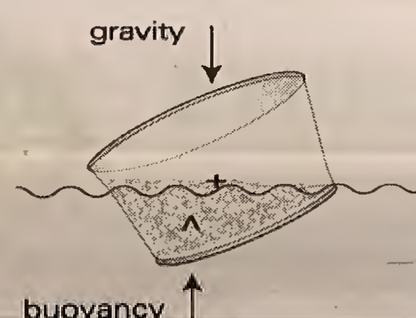
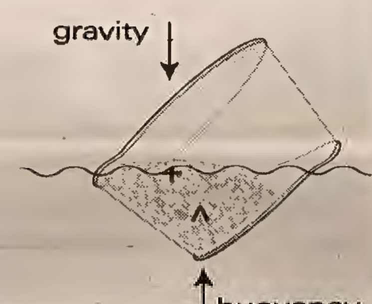


Fig. 4



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Now, move some of the dirt to one side and pat it into a new shape (see Fig. 3) and float the container again.

What's the difference?

There is a shift in the relationship between the centers of gravity and buoyancy. The center of buoyancy has freely moving fish in the hold is able to move from side to side.

Next, try moving more of the dirt to one side. At some point, the container will likely capsize (see Fig. 4).

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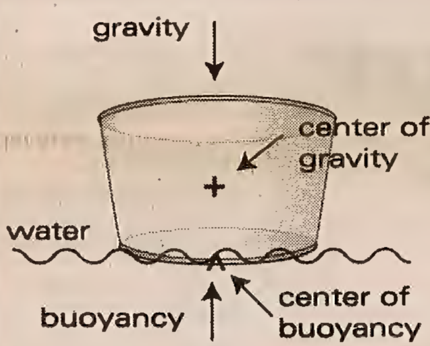


Fig. 2

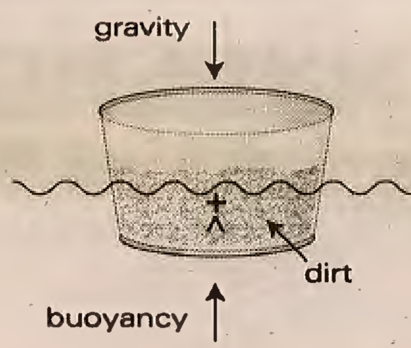


Fig. 3

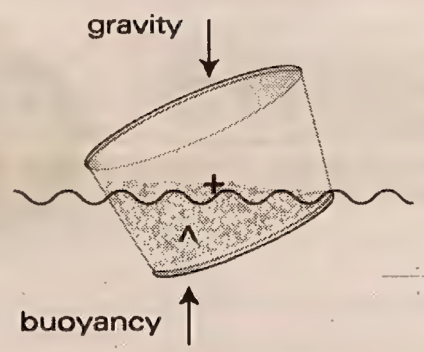
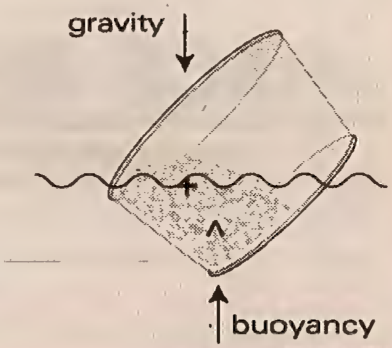


Fig. 4



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