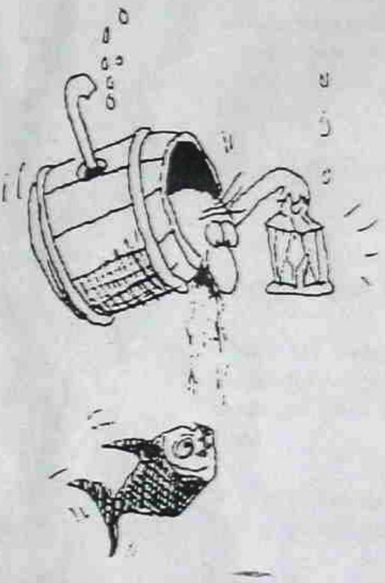

Lifting things

SECTION FIVE

Only a theory

The use of buoyancy bags is not an exact science. You can work out the weight that you need to lift and the amount of buoyancy that you need. But in practice the object is often stuck in the mud, held by incalculable suction.

You keep blowing air into the lifting bags, 2 or 3 times as much as you calculated. Then everything breaks free and heads for the surface like a rocket. The bags fly into the air, spill and the whole lot comes crashing down into the mud again. Life's like that.

What follows is only the theory. The practice is up to you.

Weight and Upthrust

There are two forces acting on a object in the water. Its weight, which tries to make it sink; the upthrust from the water which tries to make it float.

If these forces are equal, the object stays where it is. It's neutrally buoyant. This is the way that you want to be if you're floating around mid-water.

If weight is greater than upthrust, it sinks. Negative buoyancy.

If upthrust is greater than weight, it floats up. Positive buoyancy. This is the formula you need:

Upthrust = volume of water displaced x density of water

Sea water is denser than fresh water, so objects float better in sea water. If a boat sails from the sea into a fresh water canal or river, it will sink lower in the water as it progresses up river. If you're feeling lazy on a sunny day, lie on the grass at a river mouth and watch.

The density of sea water is 1.03 kg/l, 10.3 lbs per imperial gallon, 12.4 lbs per US gallon, or 64.38 lbs/ft^3.

The density of fresh water is 1.00 kg/l, 10.0 lbs per imperial gallon, 12.04 lbs per US gallon, or 62.50 lbs/ft^3.

Example 35

A diving bell displaces 5 m^3 of sea water and weighs 4.8 tonnes. Is the bell positively buoyant?

Upthrust = volume of water displaced x density of water

Volume of water displaced = 5m3

Density of sea water = 1.03 kg/l
= 1.03 tonnes/m^3 (There are 1000 kg in a tonne, 1000 l in a m^3)

Upthrust = 5 x 1.03 tonnes
= 5.15 tonnes

The bell weighs 4.8 tonnes, so its positively buoyant by (5.15 - 4.8) tonnes

Positive buoyancy = 0.35 tonnes

A positively buoyant bell won't sink, and it's good for nothing. To make it work, you have to hang some weights on it. In Example 35, you need over 0.35 tonnes to make it sink. Quite a lot more to make it sink convincingly.

Don't forget that the weights themselves will weigh less in the water because of the upthrust on them!

If the bell cable gets cut, and the divers are stranded on the seabed, they have the option of dropping the weights and heading for the surface.

Sounds great, but in practice they're better off on the seabed. They're easier to find, with sonar, they won't rocket up through the bottom of the support ship, and they won't get seasick.

Example 36

A diving bell displaces 180 ft^3 of sea water and weighs 5.2 imperial tons *(that's 2240 lbs). Is the bell positively buoyant?*

Upthrust = volume of water displaced x density of water

Volume of water displaced = 180 ft^3

Density of sea water = 64.38 lbs/ft^3

$$\text{Upthrust} = 180 \times 64.38 \text{ lbs} = 11588.4 \text{ lbs} = \frac{11588.4}{2240} \text{ tons}$$

$$= 5.17 \text{ tons}$$

The bell weighs 5.2 tonnes, so it's negatively buoyant by (5.2 - 5.17) tonnes

Negative buoyancy = 0.03 tonnes

So this one's going to sink, without any added weight.

If you're ever doing bell buoyancy tests for real, don't forget to include the weight of the divers and all their equipment.

Example 37

A block of concrete, 1m by 1m by 1m, is lying on the seabed. The density of concrete is 2400 kg/m^3. How much force is required to lift the block clear of the seabed?

Assume that the block is lying on a hard gravel bottom, so you don't have any suction problems.

The first step is to find the weight of the block:

Weight of block = Volume x density

$$\text{Volume} = 1 \times 1 \times 1 \text{ m}^3 = 1 \text{ m}^3$$

$$\text{Density} = 2400 \text{ kg/m}^3$$

$$\text{Weight} = 1 \times 2400 \text{ kg}$$

$= 2400$ kg *(tough calculation!)*
$= 2.4$ tonnes

In air, it would take 2400 kg to lift it. But you're on the bottom of the sea, so there's an upthrust.

$$\text{Upthrust} = \text{volume of water displaced} \times \text{density of water}$$

$$\text{Volume of water displaced} = 1 m^3$$

$$\begin{aligned}\text{Density of sea water} &= 1.03 \text{ kg/l} \\ &= 1.03 \text{ tonnes/m}^3\end{aligned}$$

$$\begin{aligned}\text{Upthrust} &= 1 \times 1.03 \text{ tonnes} \\ &= 1.03 \text{ tonnes}\end{aligned}$$

$$\begin{aligned}\text{Force required to lift the block} &= (2.4 - 1.03) \text{ tonnes} \\ &= 1.37 \text{ tonnes}\end{aligned}$$

It only weighs 1.37 tonnes in the water. Don't forget, though, that it'll weigh 2.4 tonnes when you lift it out of the water! You don't get much upthrust from air.

If the ship is rolling, it'll weigh more than 2.4 tonnes. The acceleration of the block will add to its weight. A sudden jerk may give you a shock loading far greater.