

Materials

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Learning Outcome

I highly recommend you to finish this checklist to determine whether you've achieved the learning objectives.

- define and use density
- define and use pressure and calculate the pressure in a fluid
- derive and use the equation: $\Delta p = \rho gh$
- explain and use Archimedes' principle
- use a difference in hydrostatic pressure to explain and calculate upthrust

Leadin

Everyone seems to hear about the story about how Archimedes weighed the king's crown. And the famous word 'Eureka', you can even find the line in "[Interstellar](#)¹". The physical principles behind it was really astonishing.



¹ Bilibili Unlimited Mining Co.

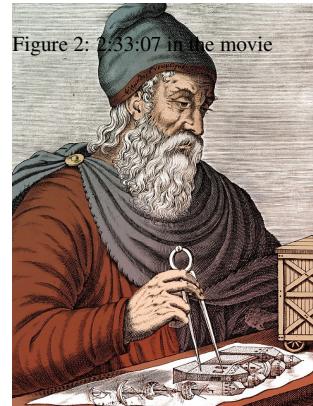


Figure 1: Archimedes
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Density

You've already know the density of an object is expressed as the mass per unit volume.

Summary

$$\rho = \text{_____}$$

One thing to mention is to care for the SI unit. Although kg m^{-3} is the most standard one, but g cm^{-3} or kg L^{-1} are still common, even for same materials, if expressed in different unit, the values would differ. For example: water is _____ kg m^{-3} or _____ kg l^{-1} or g cm^{-3} .

Task

Refer to any resources taht are accessible to you to find the density of the following materials (in both g cm^{-3} and kg m^{-3}).

- air
- hydrogen gas
- helium gas
- ice
- water
- olive oil
- mercury(liquid)
- wood
- glass

- steel
- silver
- gold

Pressure

definition of pressure

Pressure is the normal (or perpendicular) force acting per unit cross-sectional area, the defining formula for pressure is:

Summary

$$p = \text{_____}$$

Several things to notice are that:

1. Pressure is a scalar/vector quantity
2. the unit for pressure is pascal, Pa. The SI base unit is _____.

Pressure in liquid

This is also the content that you've already learned, the pressure from a liquid is determined by the following factors: _____, _____ and . The formula for hydraulic pressure is

Summary

$$\Delta p = \text{_____}$$

Let's deduce the thing using the figure 3

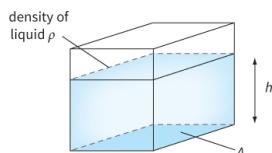


Figure 3: A simple model to derive the hydraulic pressure in water

And the most interesting thing about the liquid pressure is that, the hydraulic pressure at certain depth has nothing to do with the shape of the liquid, which means the pressures in the figure 4 are all the same despite the shapes of container are different.

And a famous application of hydraulic pressure is communicating vessels as shown in figure 5.



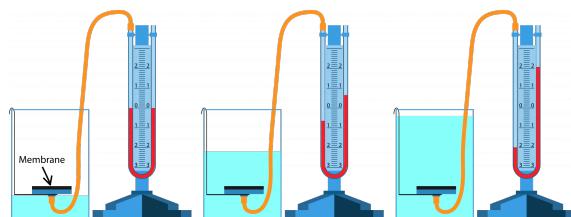
Figure 4: all the pressure are same



Figure 5: The height of the water will be exactly the same

Manometer and Barometer

Using the principle of hydraulic pressure, manometer and barometer was created to measure gas or liquid pressure².



² the formation of gas pressure is different from that of the hydraulic pressure, we will talk about it in Ideal Gases
Figure 6: Try to explain why the difference between two coloumn are becoming larger

The second equipment is called barometer which is invented by Evangelista Torricelli³. He is famous for measuring the atmospheric pressure using barometer, and in memory of his great devotion, the unit torr is used when measuring the atmospheric pressure. The diagram of a barometer is shown as in figure 7.

Task

Explain the rationale of manometer and barometer.

Convert 1 torr to Pa

³ Guess his country?

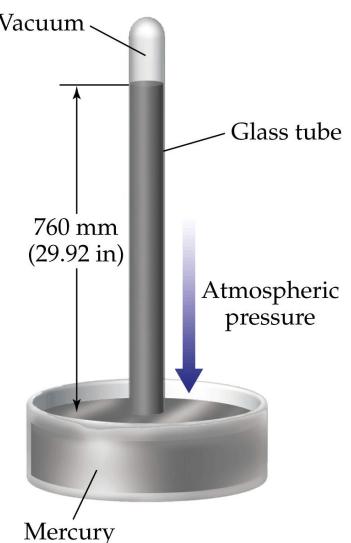


Figure 7: A quite simple mercury barometer

Archimedes Principle

Now, Archimedes principle finally comes, it states as following:

Summary

The upthrust acting on a body is equal to the weight of the liquid or gas that it displaces.

$$F_{\text{upthrust}} = \rho g V$$

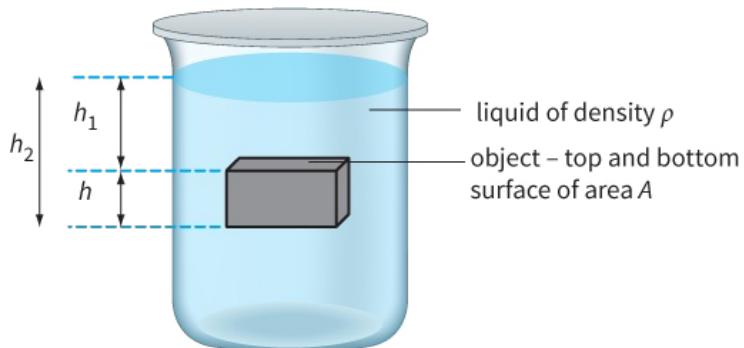


Figure 8: Difference in the pressure at different depth cause upthrust of the object

Task

Using the figure 8 to deduce the formula of Archimedes Principle

Explain how this principle can be used to tell whether the crown is mixed with silver given that the crown has the equal mass as if it is made purely of gold.