July 22, Week 8

Today: Fluids, Chapter 13 and Periodic Motion, Chapter 14

Final Exam, Thursday. 9:00-10:30 or 11:00-12:15

Four review questions on the final will come from tests #1, 2, 4, and 6. There will be six questions based on new material. You may skip two questions.

Fluids and Density

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To find the pressure in a fluid, we need its density, ρ. (To be more precise, we use its mass density $\Rightarrow$ the ratio of its mass to its volume)

$$\boxed{\rho = \frac{m}{V}}$$

Unit: kg/m^3

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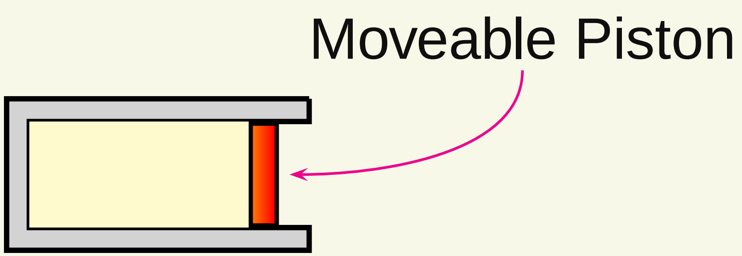
Since the book uses it so much: $\boxed{1g/cm^3 = 1000\,kg/m^3}$

Density Exercise

A gas is sealed in a container that has a moveable piston on one side (so the volume can change). If the volume is cut in half, which of the following is a correct statement?



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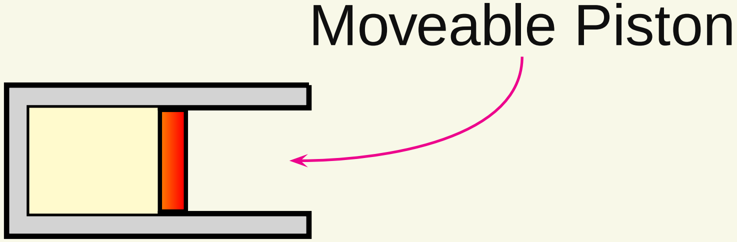

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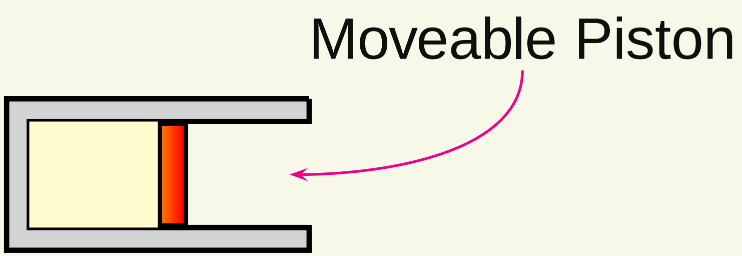
(a) Both the mass and the density will double.



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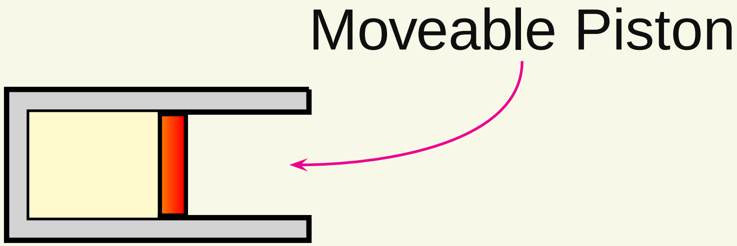

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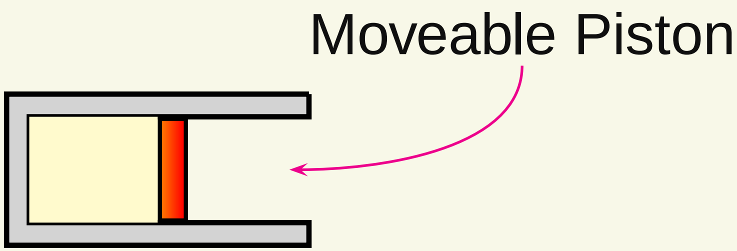

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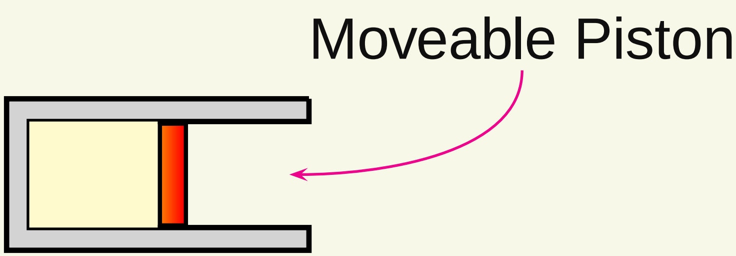

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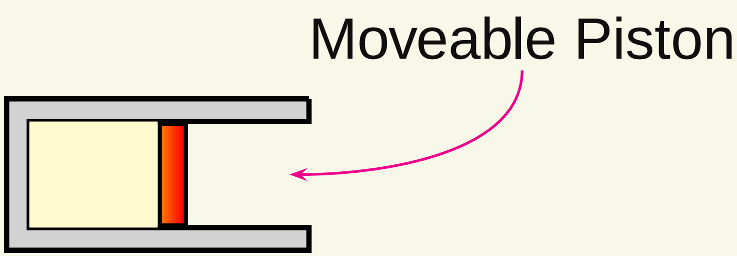

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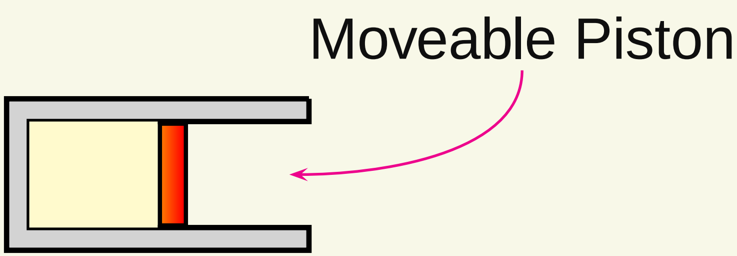

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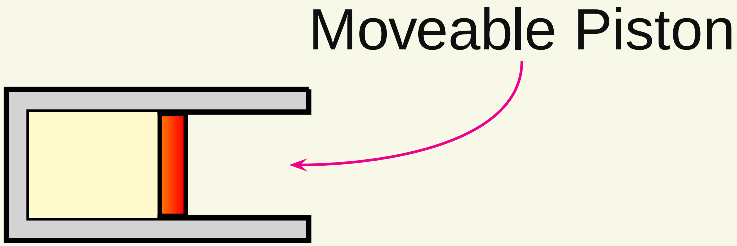

The mass is determined by the number of molecules. Since the number isn't changing neither is the mass. $\rho = m/V \Rightarrow$ cutting V in half while keeping m fixed will double the density.

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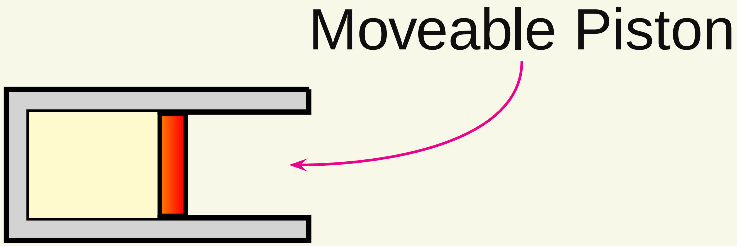

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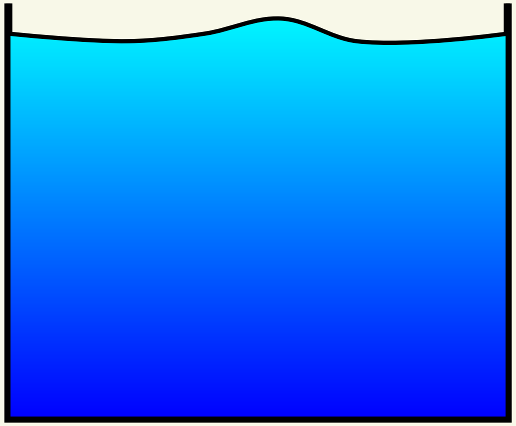
Liquids (and solids) are essentially incompressible $\Rightarrow$ cannot change their volume without adding or removing more mass $\Rightarrow$ they have a constant density.

Pressure and Depth

The pressure in a fluid increases with depth below the surface.



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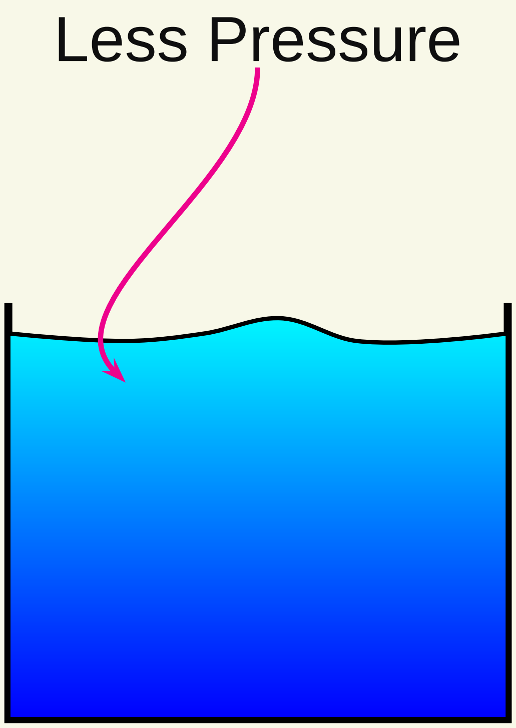

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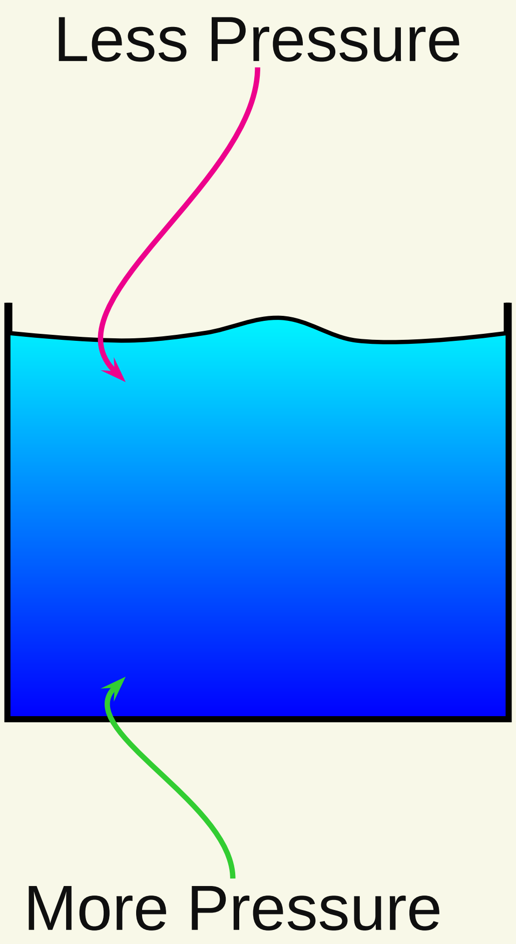

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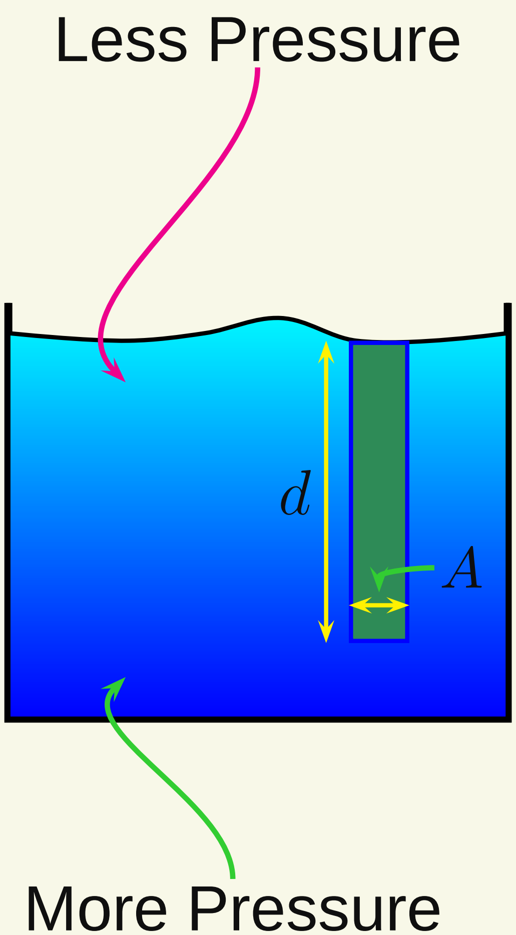

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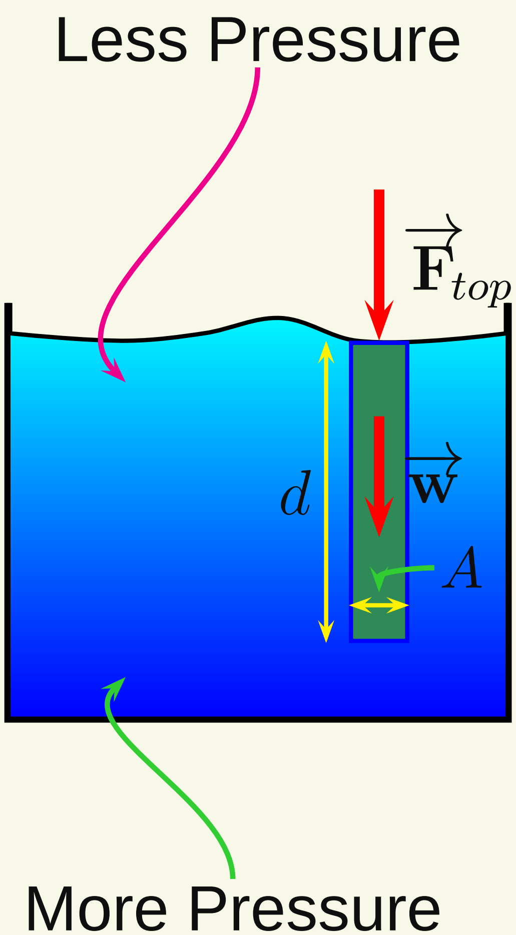

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As well as the weight of the fluid there is a force on the top of the cylinder from whatever is above it. (Usually air.)

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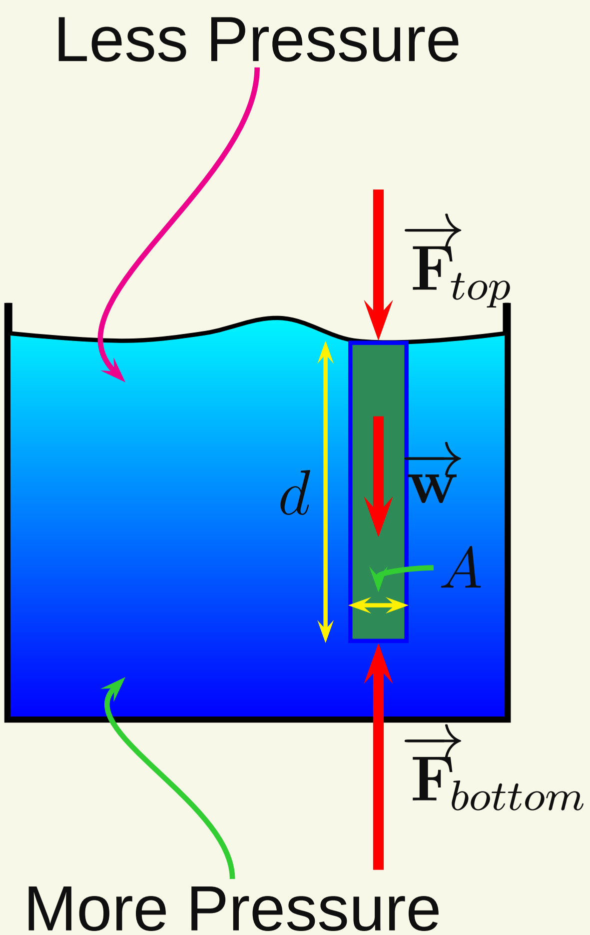

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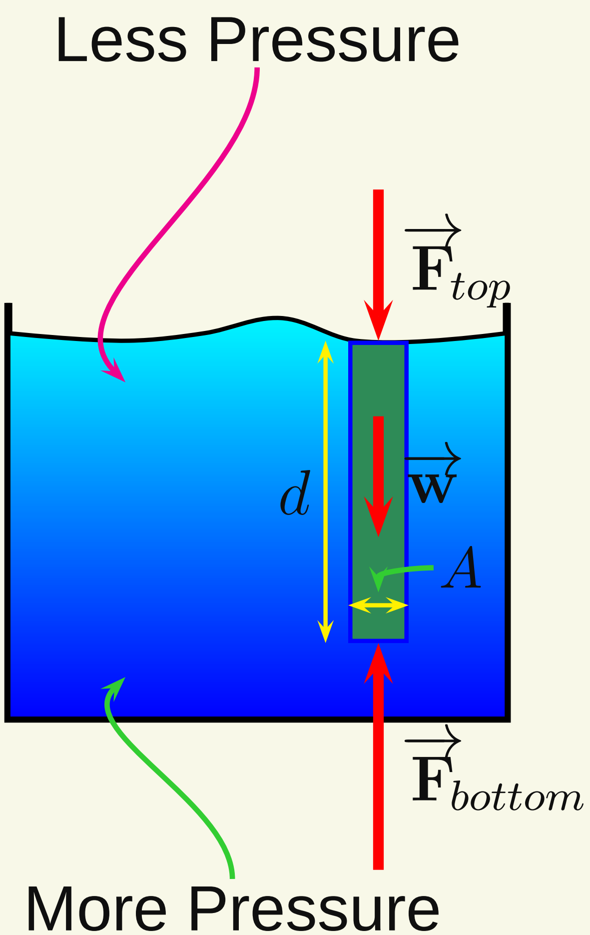

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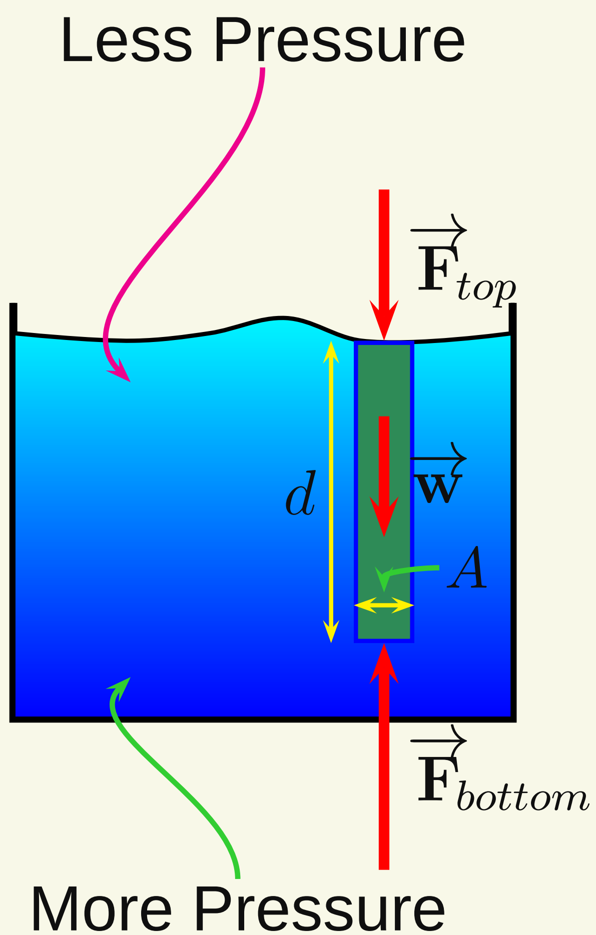

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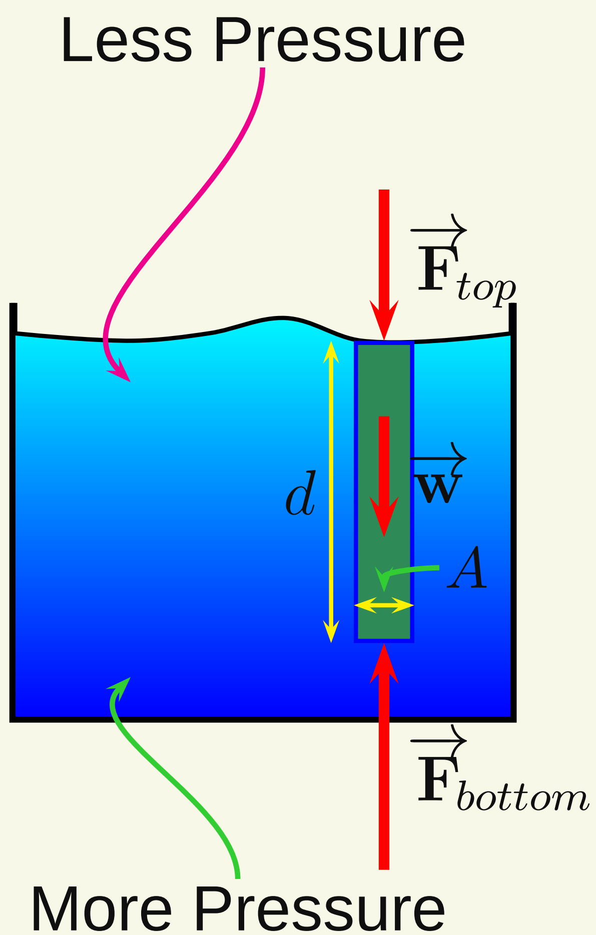

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$w = mg$, $\rho = m/V$, and $V = Ad \Rightarrow w/A = \rho g d$

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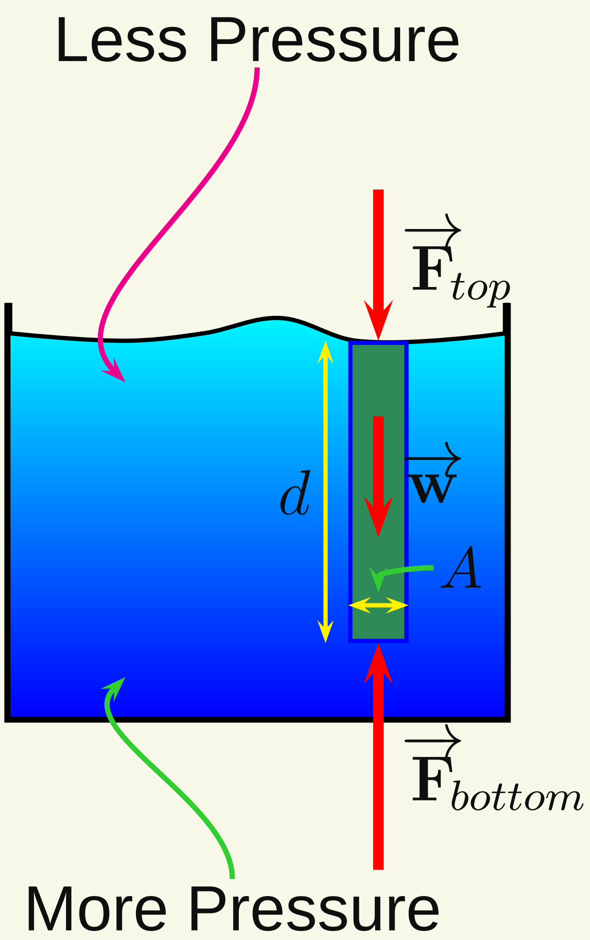

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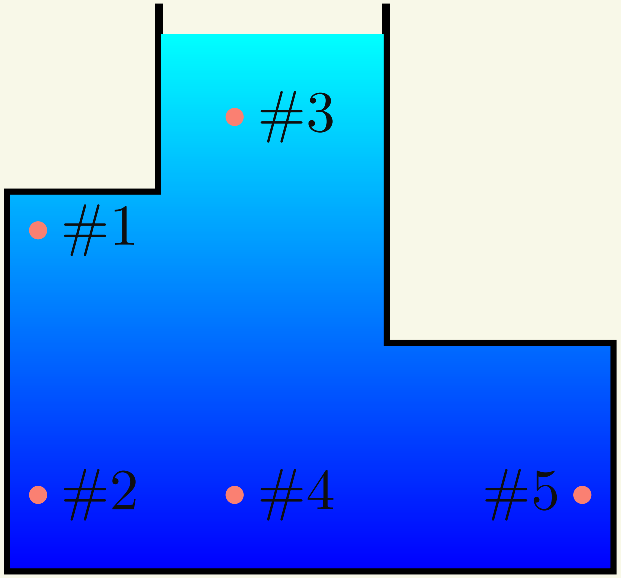
$$p_{bottom} = p_{top} + \rho g d \Rightarrow \boxed{p = p_0 + \rho g d}$$

Depth Exercise

Which is the correct ranking, from smallest to largest, of the pressure values in the following container?



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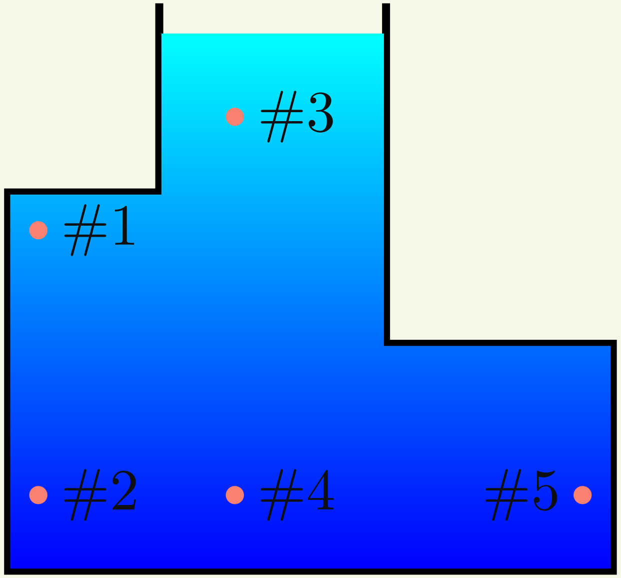

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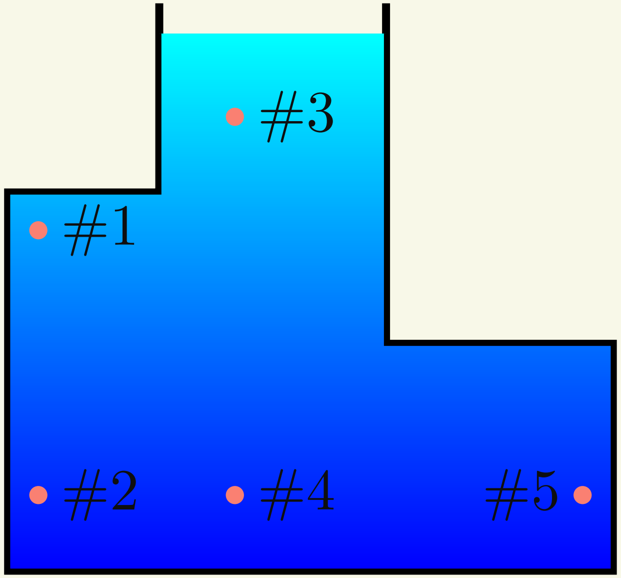

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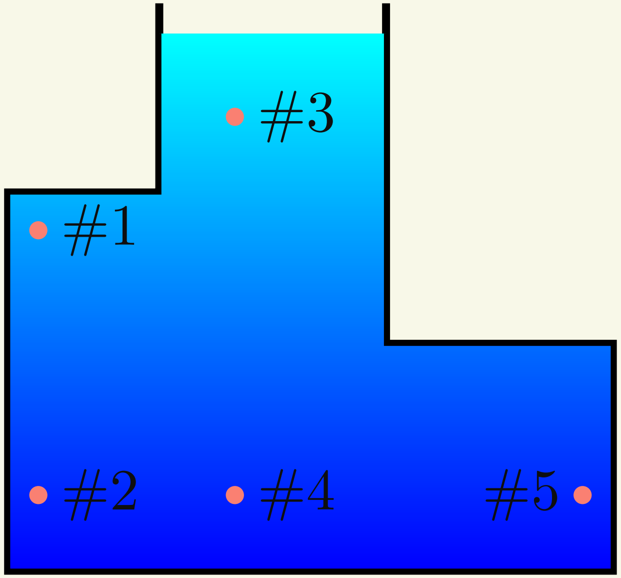

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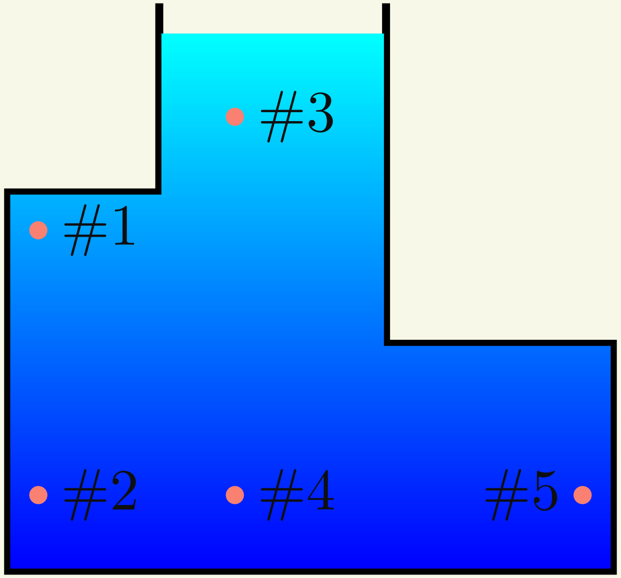

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(d) $3, \quad 1, \quad 2 = 4 = 5$

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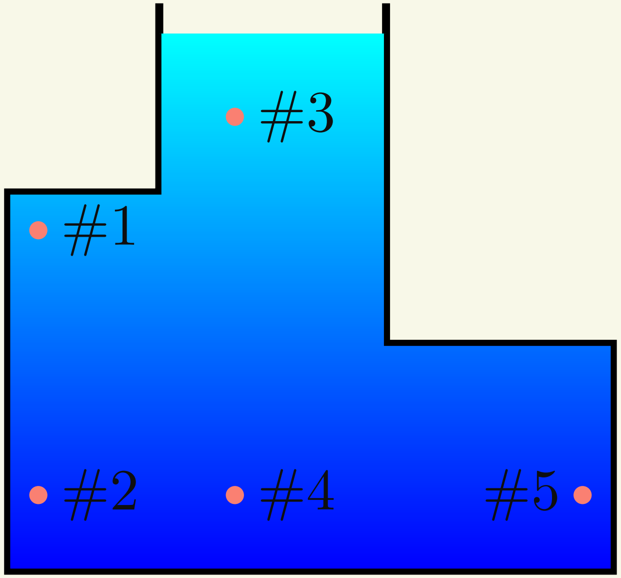

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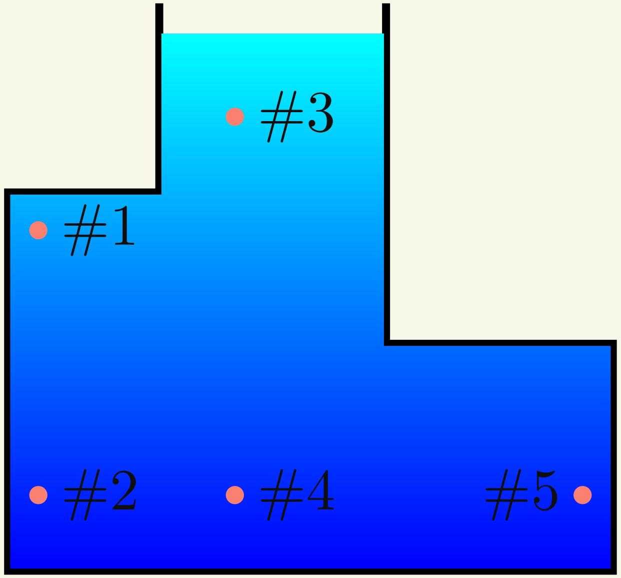

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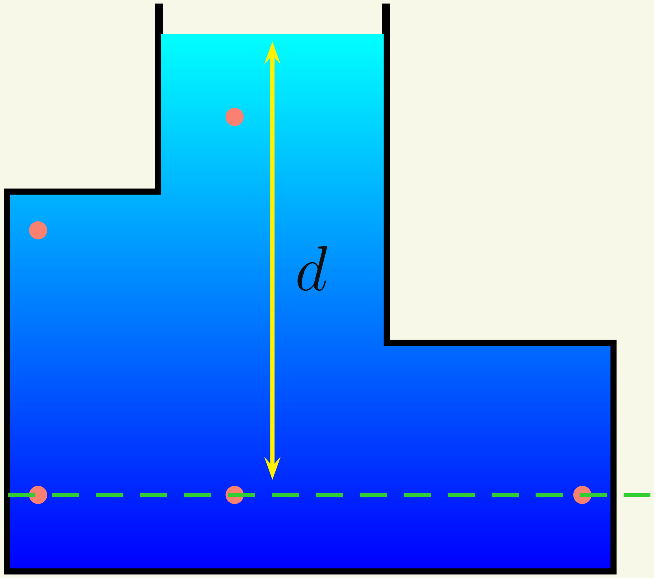
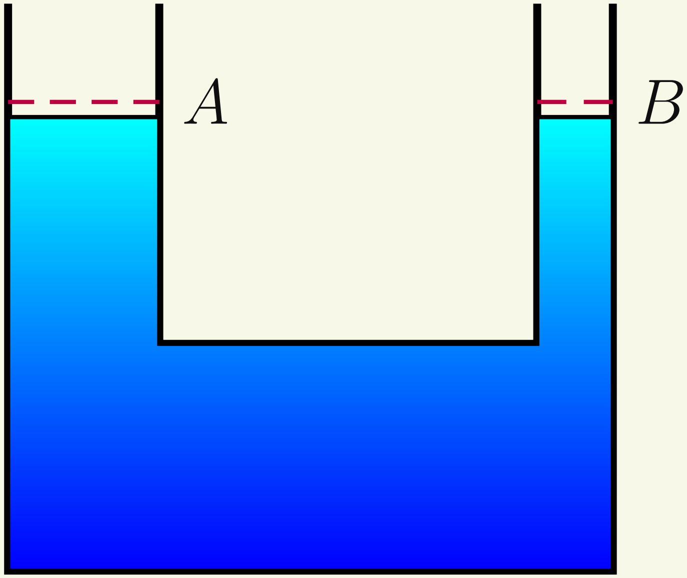


(d) $3, \;\; 1, \;\; 2 = 4 = 5$

All points on a horizontal line in a fluid are at the same pressure

Depth Exercise II

What is wrong with this figure?



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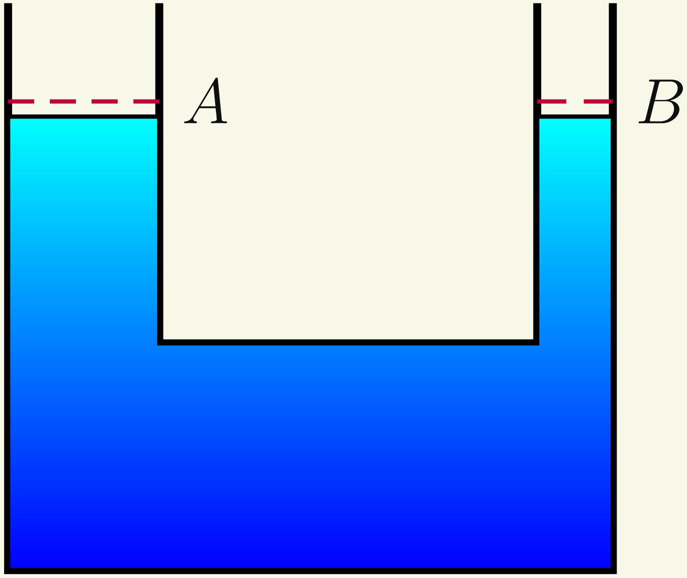
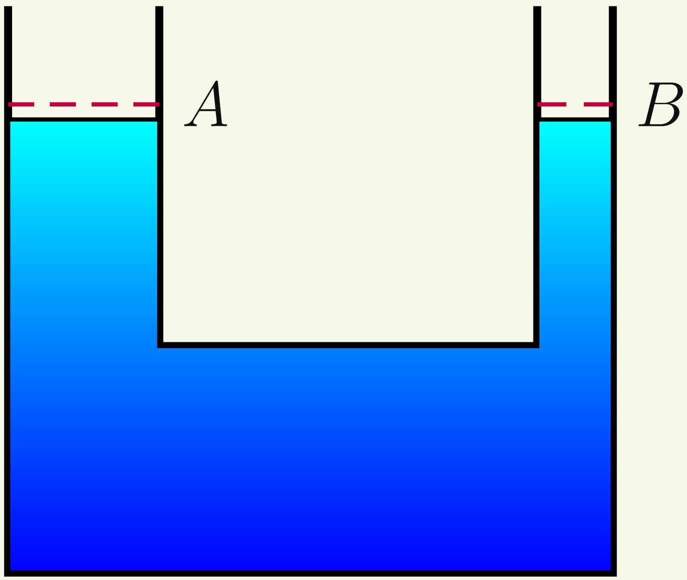


(a) The water on side A should be higher than side B.

What is wrong with this figure?



(a) The water on side A should be higher than side B.

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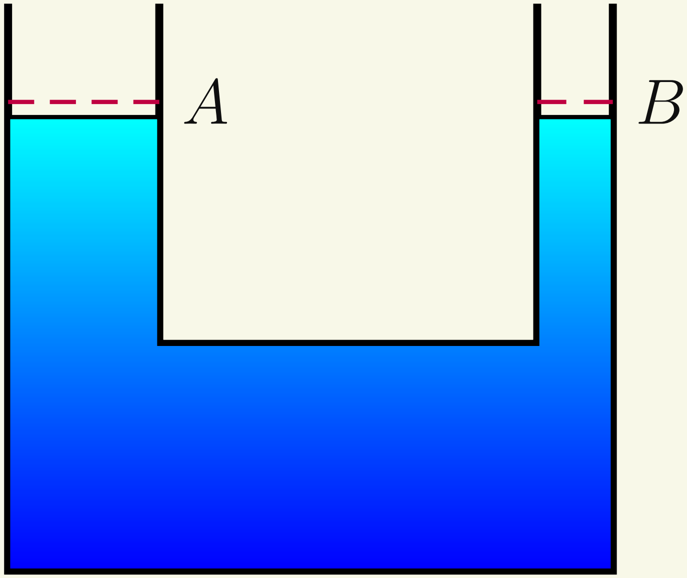

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(c) There is nothing wrong with this figure.

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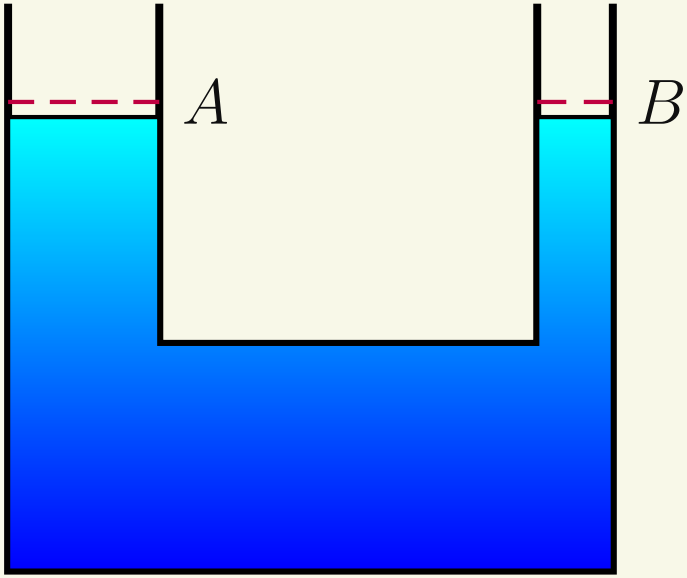

(a) The water on side A should be higher than side B.

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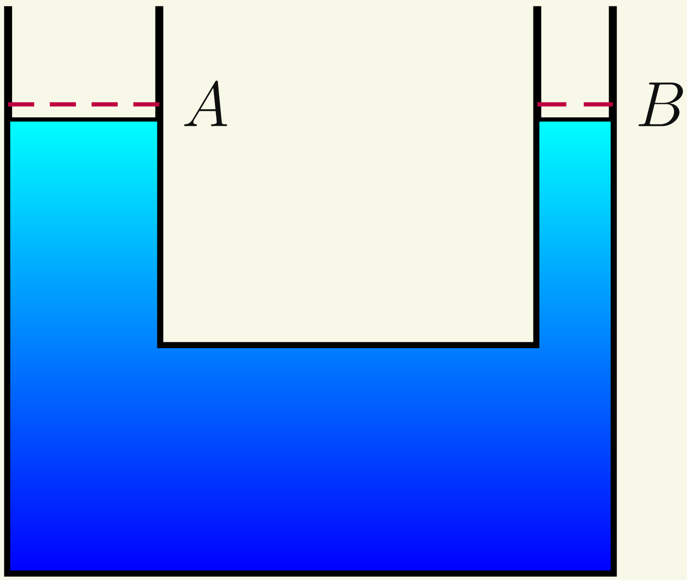

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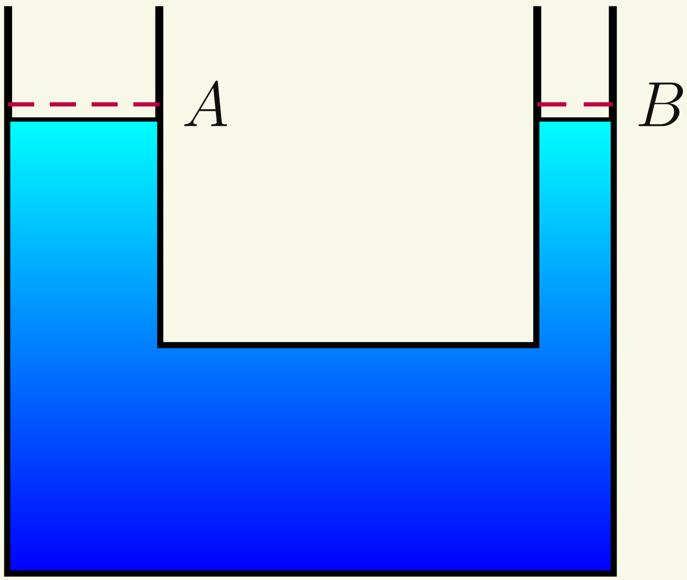

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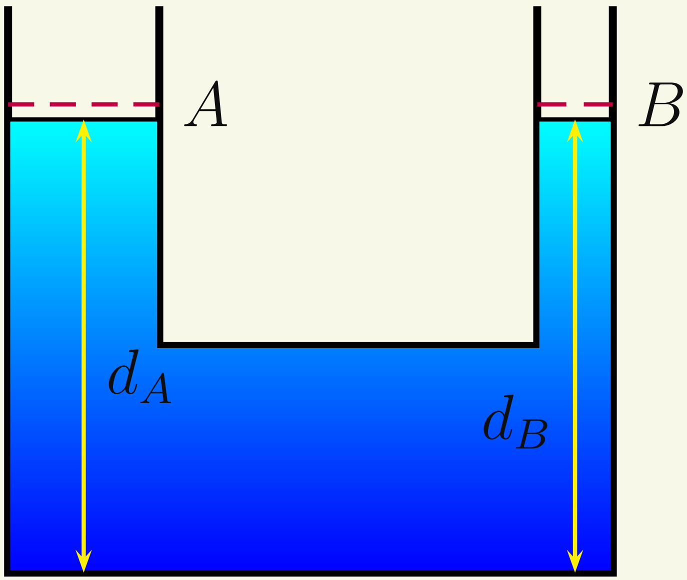

(c) There is nothing wrong with this figure.

Pressure is determined only by the vertical amount of fluid not the width of the container. Since the depths are the same on both sides, the pressures are the same, and the fluid will stay at rest.

Buoyancy

Replacing a fluid with a different material causes an upwards buoyant force

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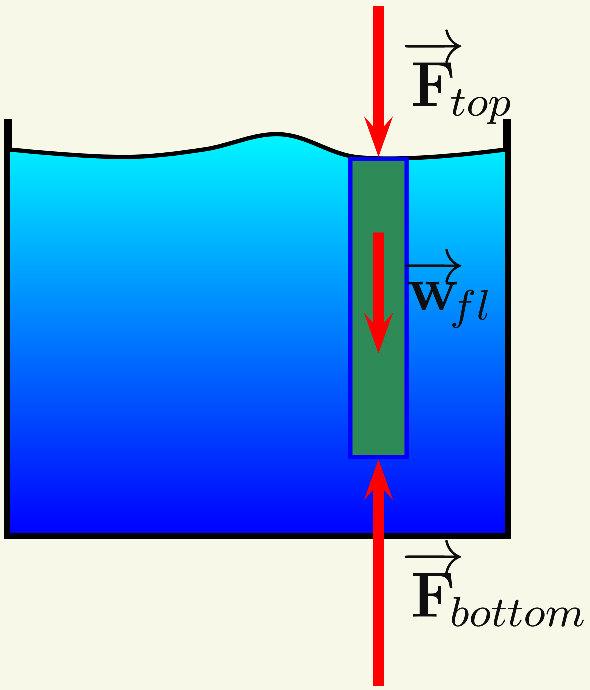
Replacing a fluid with a different material causes an upwards <u>buoyant</u> force



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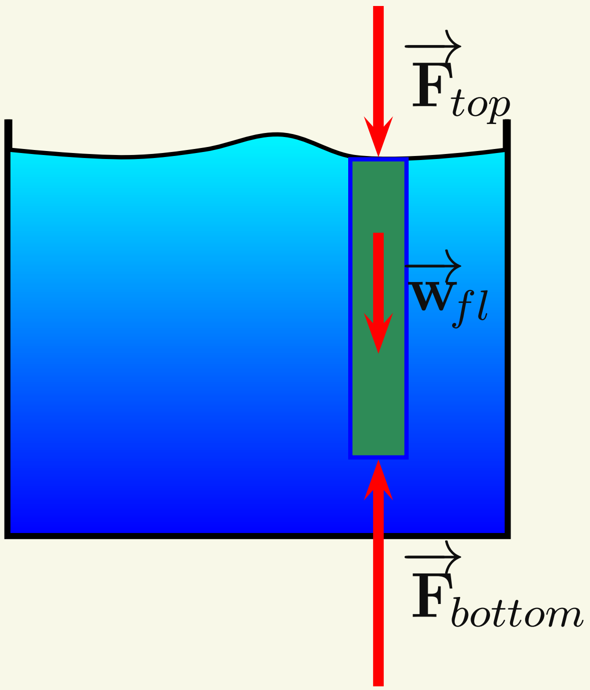

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$F_{bottom} = F_{top} + w_{fluid}$

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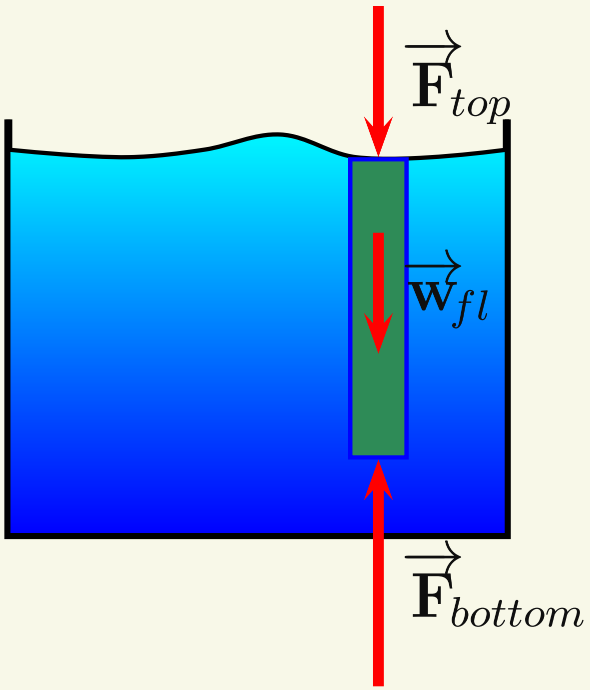

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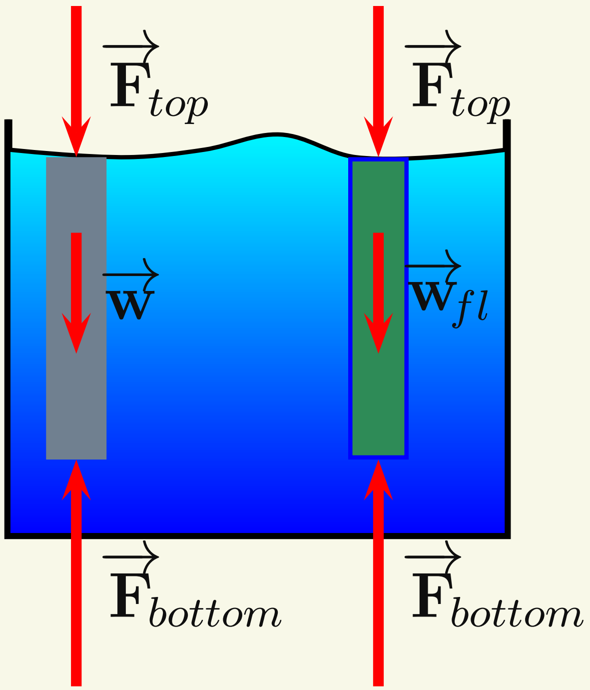

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If we submerge an object with the same size as the cylinder, it will have the same F_{bottom} and F_{top} $\Rightarrow$ an overall upward buoyant force, $\overrightarrow{\mathbf{F}}_B$

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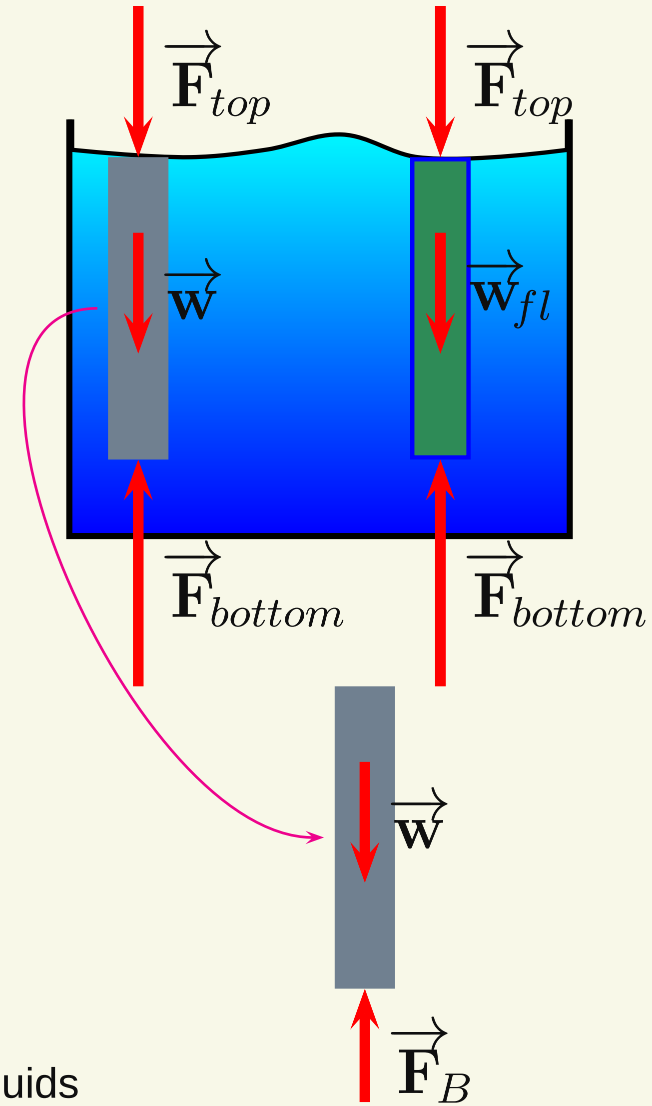

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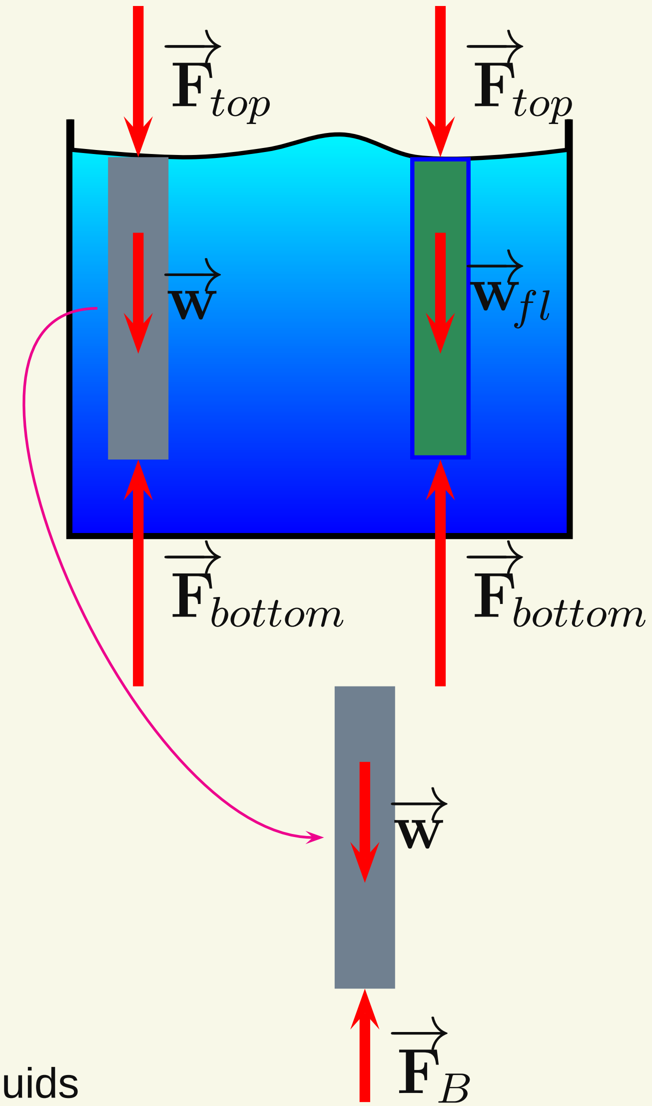

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$$F_B = F_{bottom} - F_{top} = w_{fluid} = (m_{fluid})\, g$$

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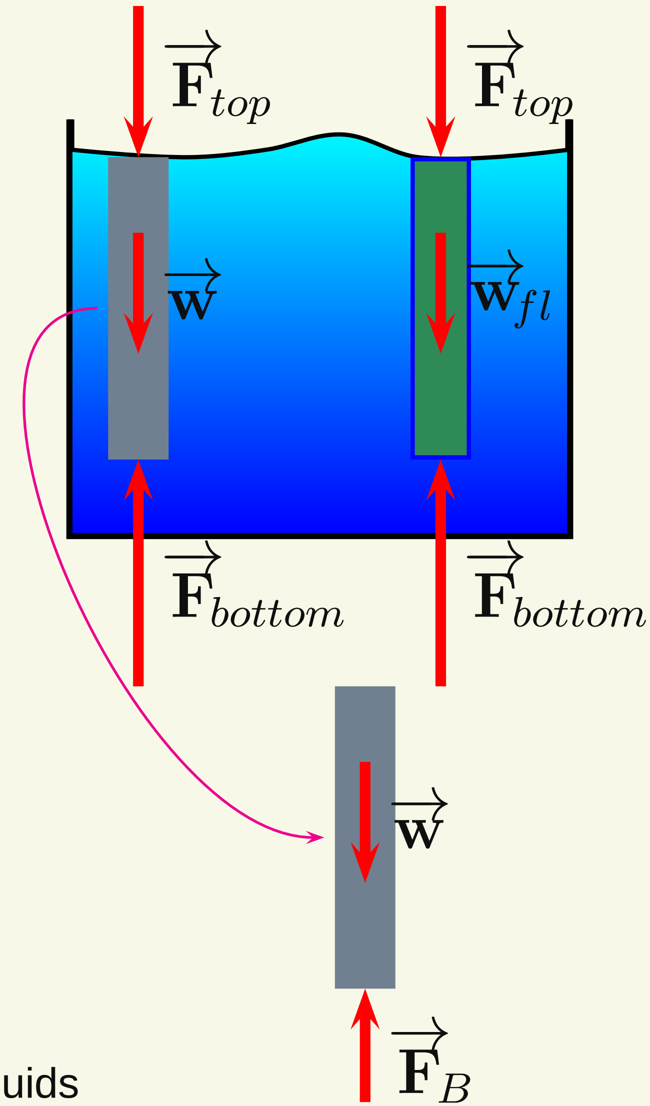

The *fluid* is not moving $\Rightarrow \sum F_y = 0 \Rightarrow$ $F_{bottom} = F_{top} + w_{fluid}$

$$\Rightarrow F_{bottom} - F_{top} = w_{fluid}$$

If we submerge an object with the same size as the cylinder, it will have the same F_{bottom} and F_{top} $\Rightarrow$ an overall upward buoyant force, $\overrightarrow{\mathbf{F}}_B$

$$F_B = F_{bottom} - F_{top} = w_{fluid} = (m_{fluid})\, g$$

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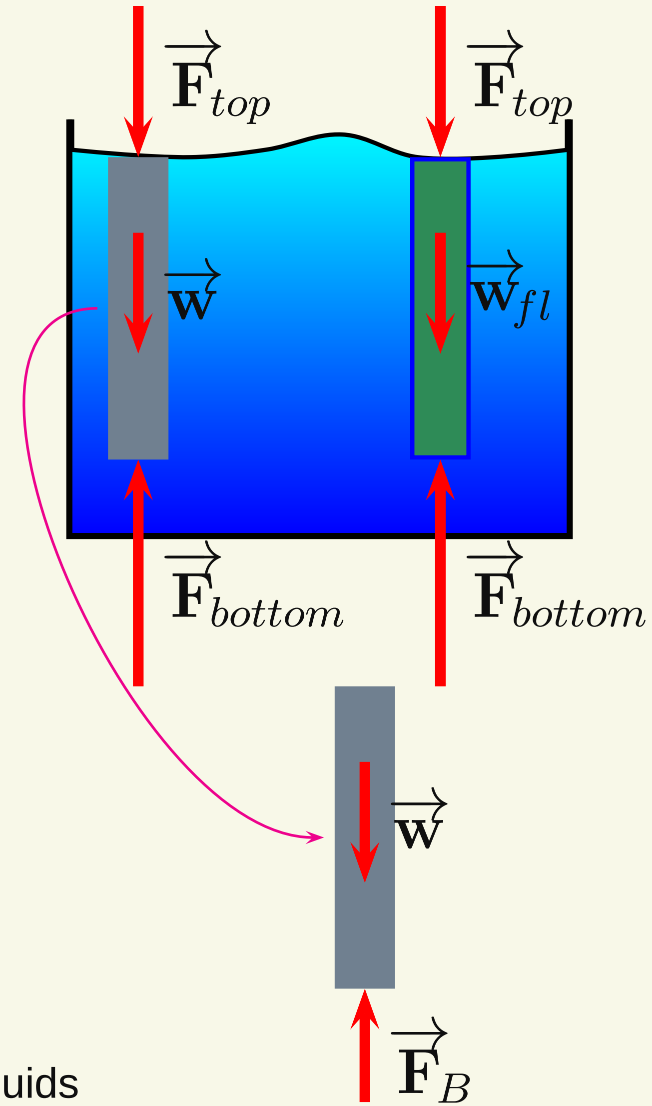

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By using V_f = volume of the fluid displaced, we can do any size object that doesn't have to be completely submerged

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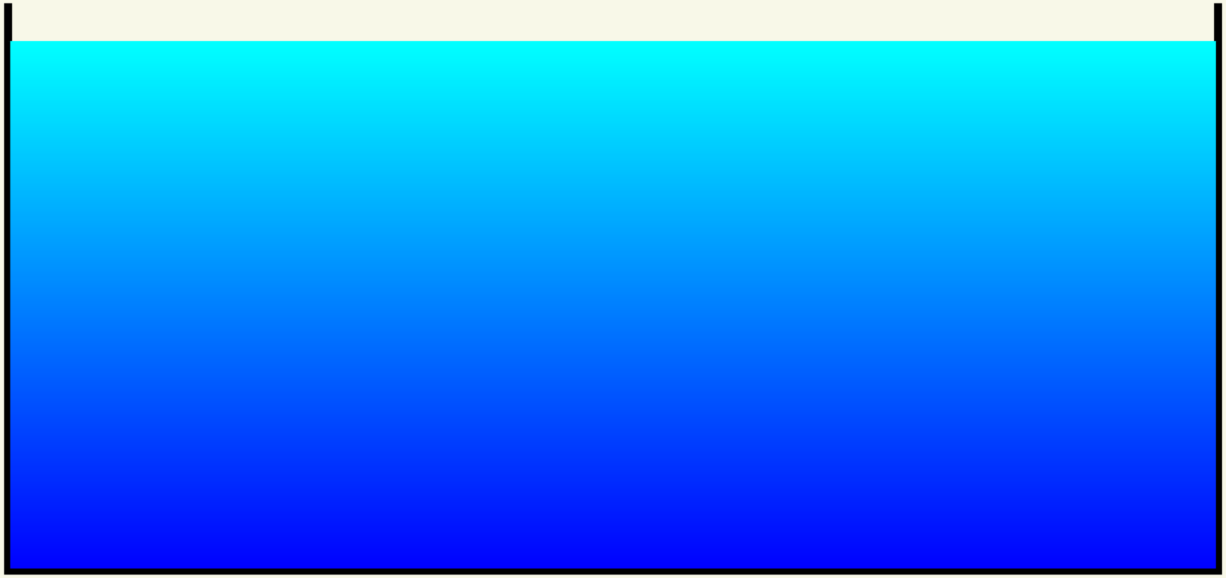
Which of the blocks shown has a density greater than the fluid in which they are submerged/floating?



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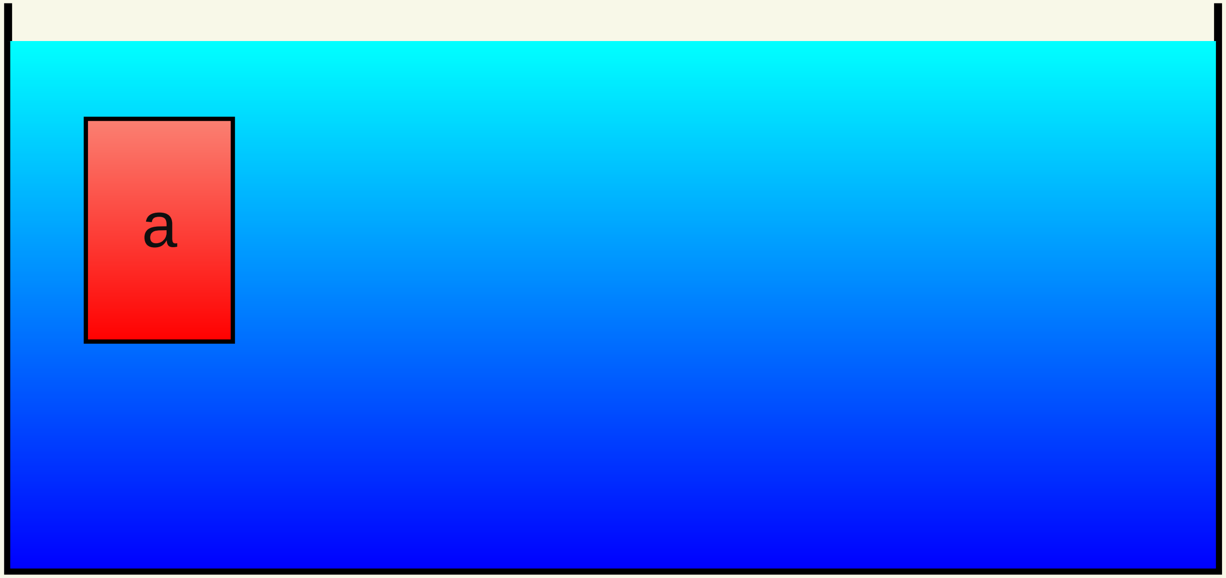

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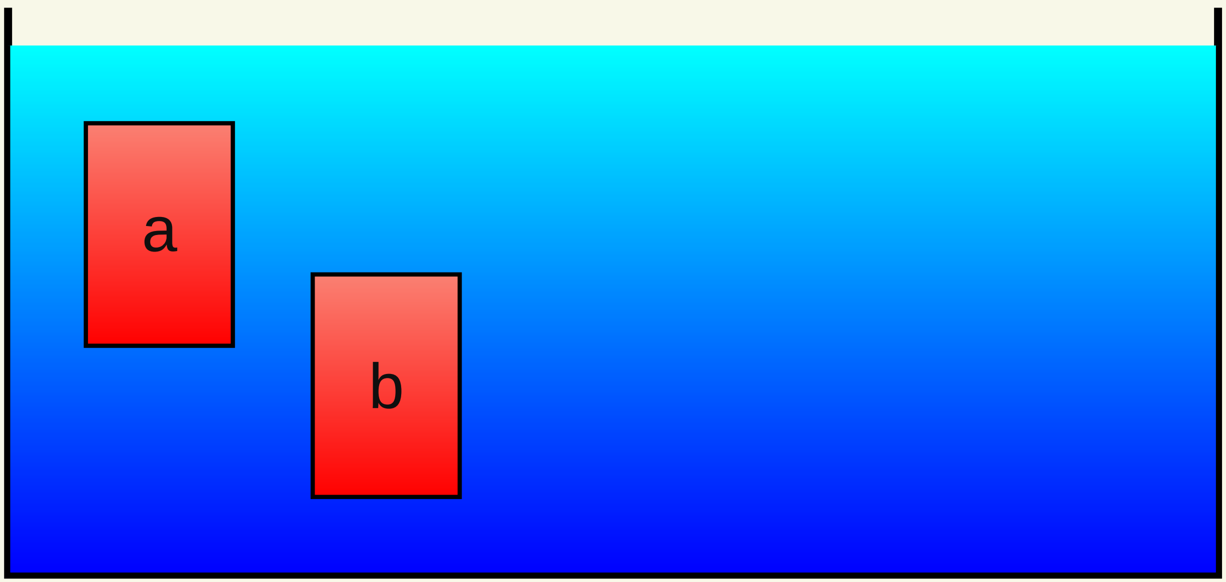

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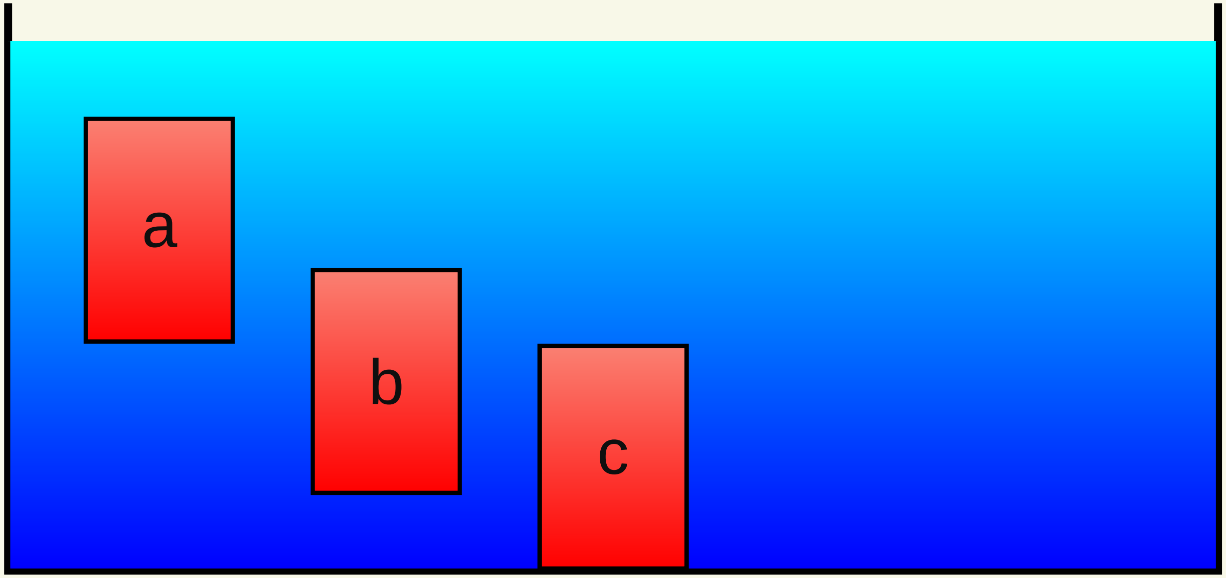

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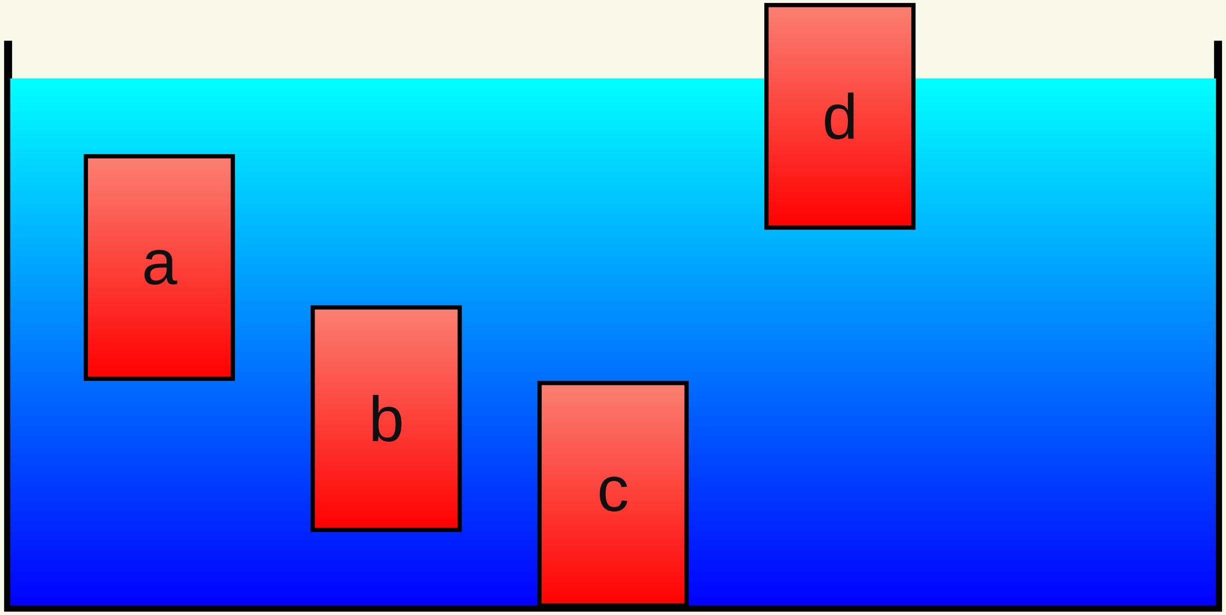

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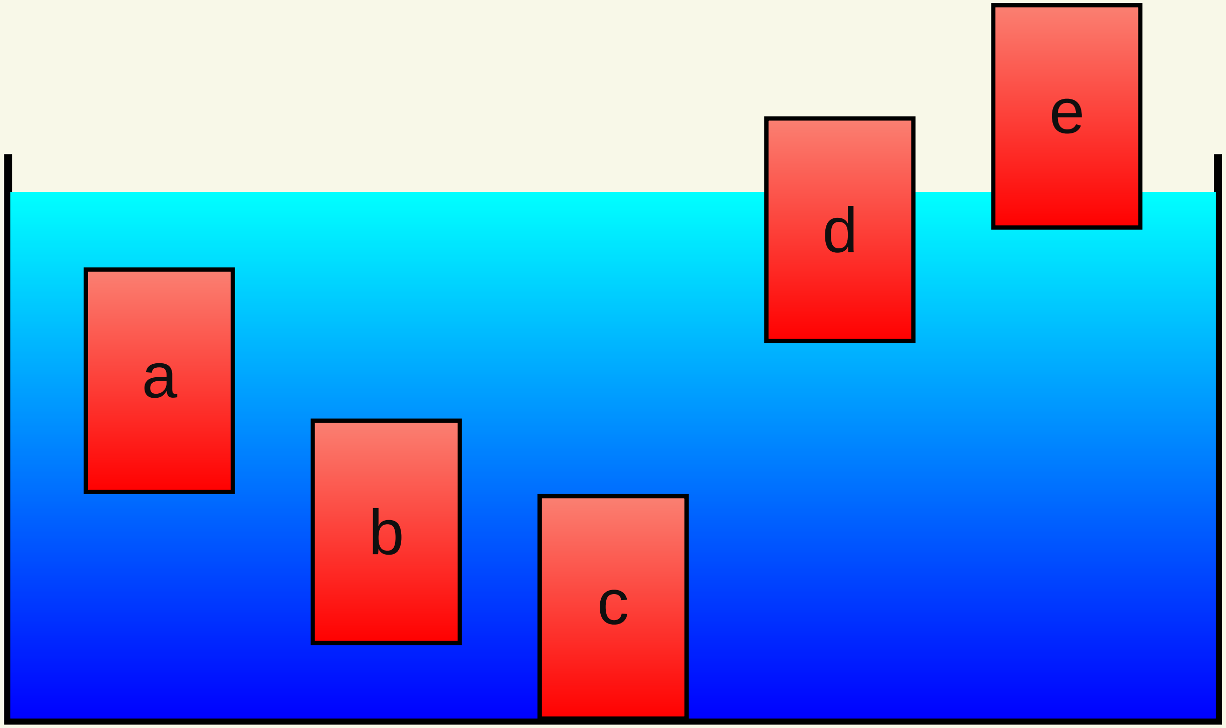

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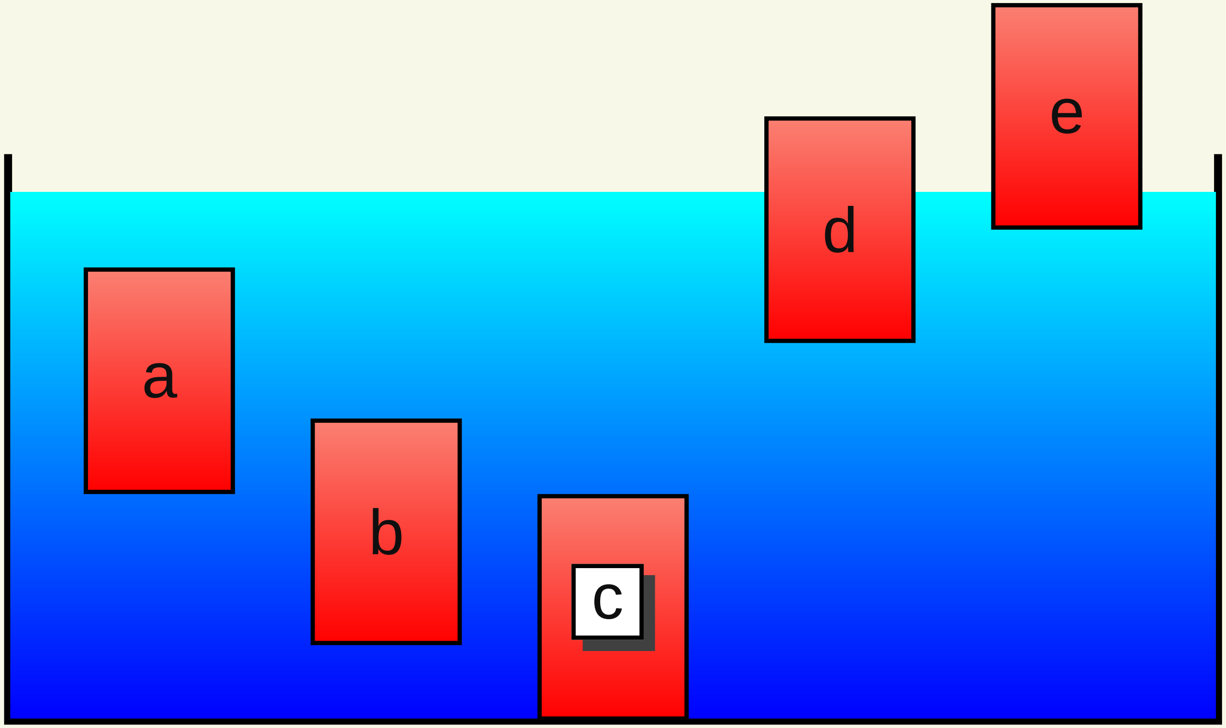

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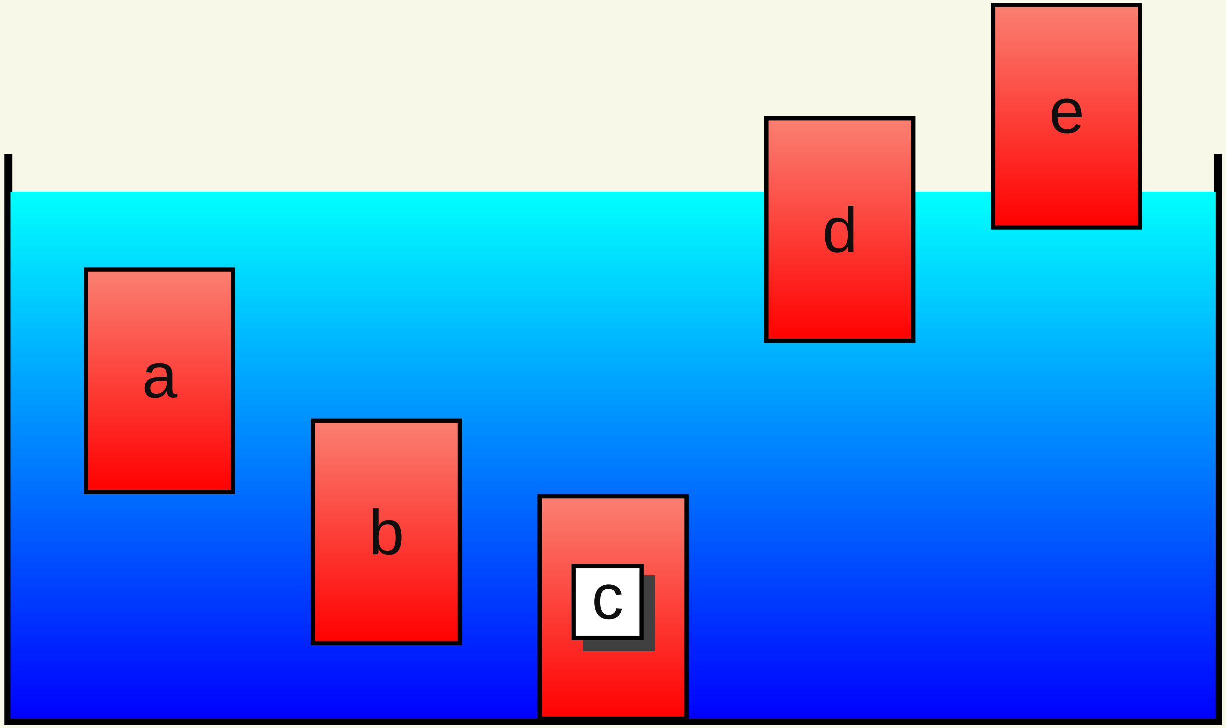

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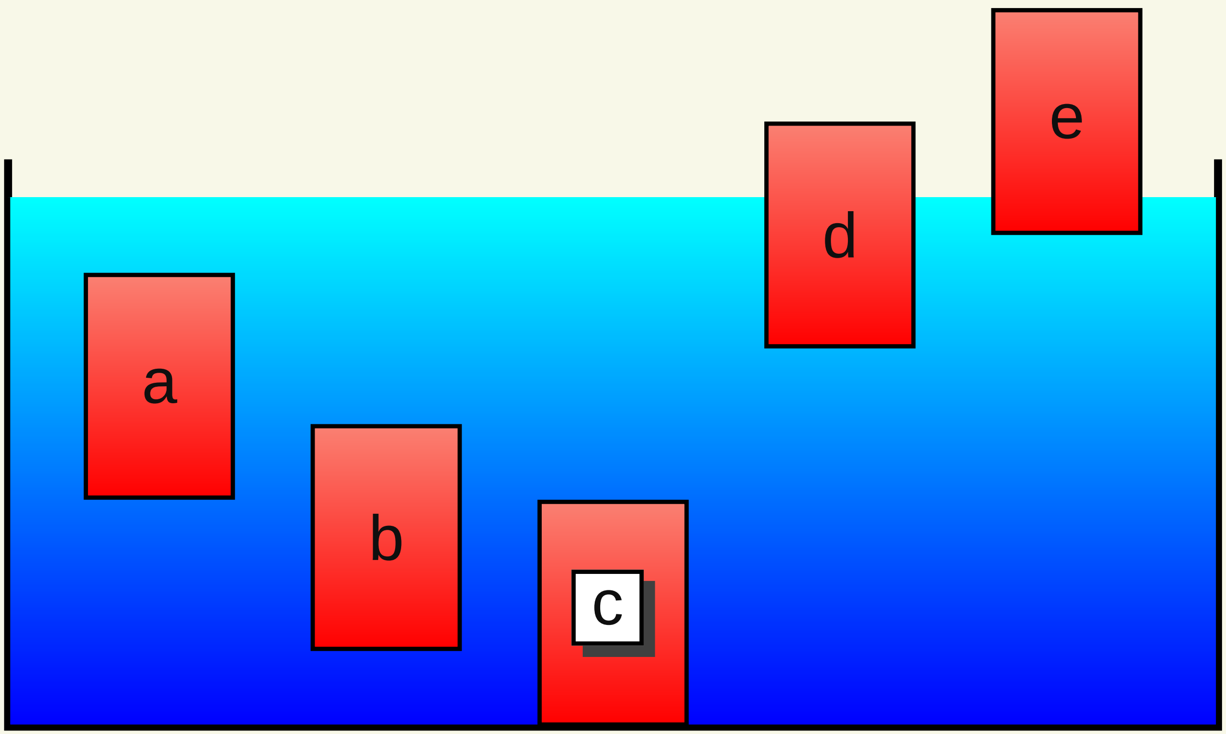

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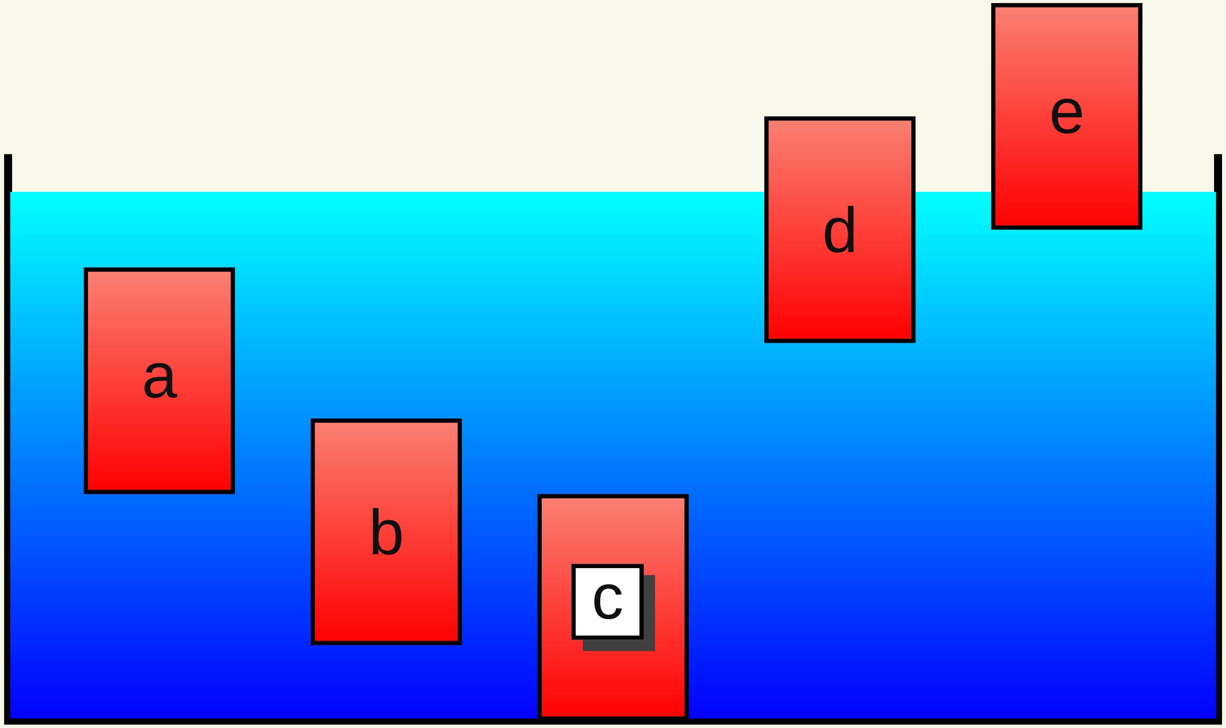

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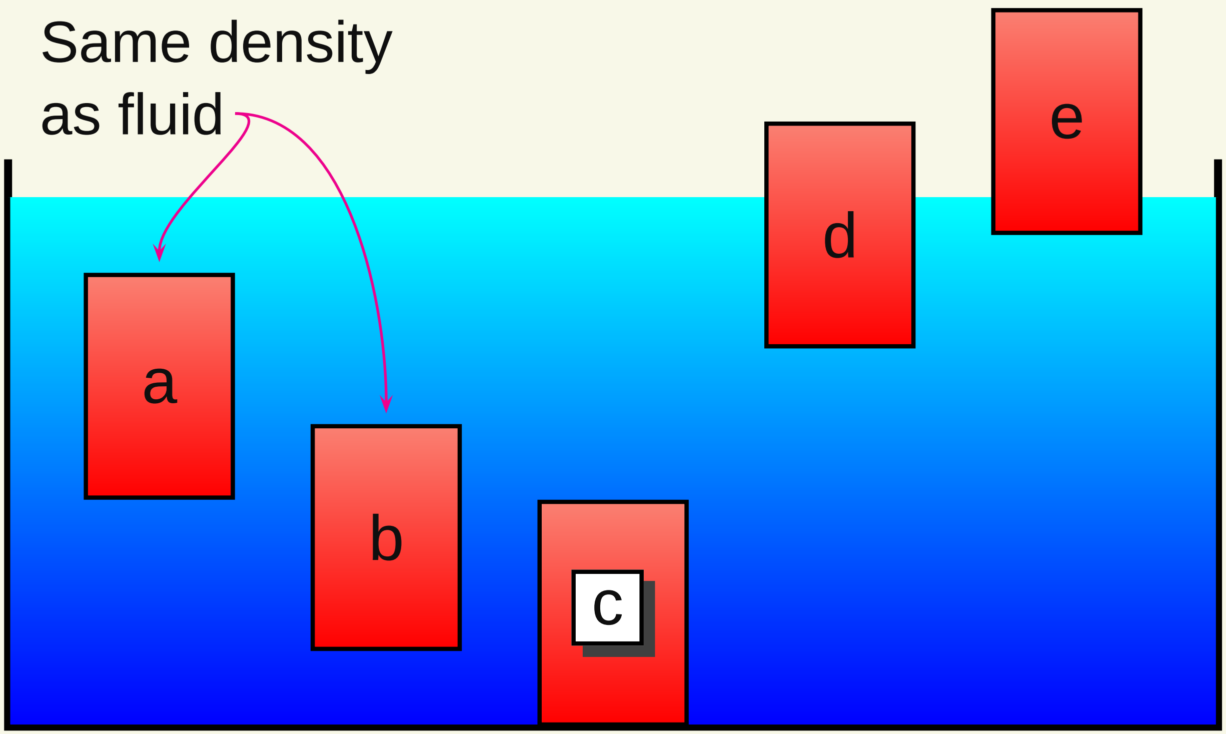

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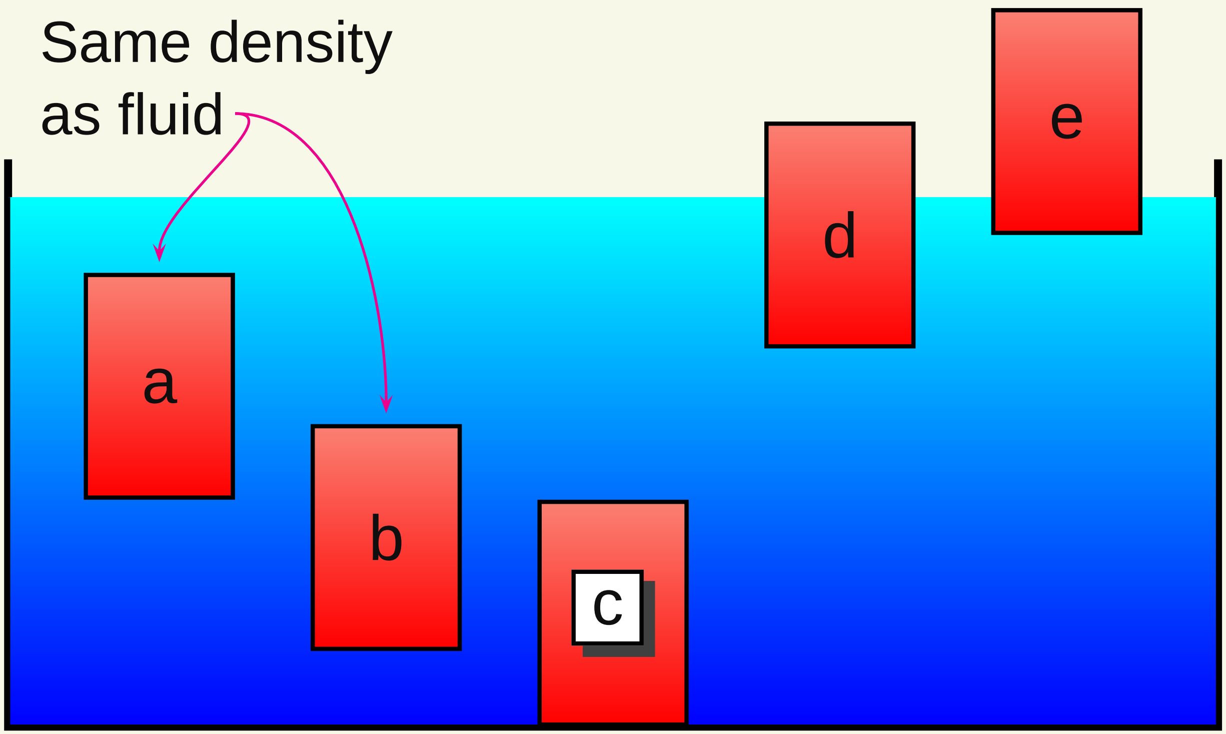

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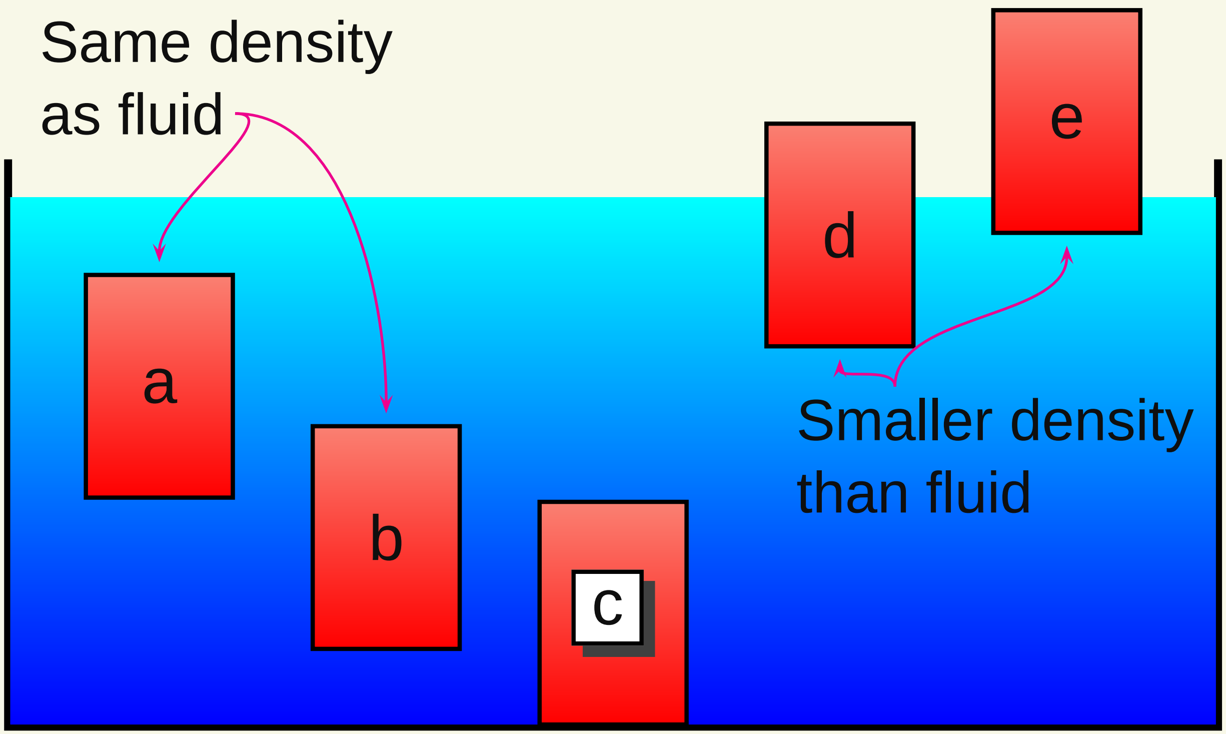

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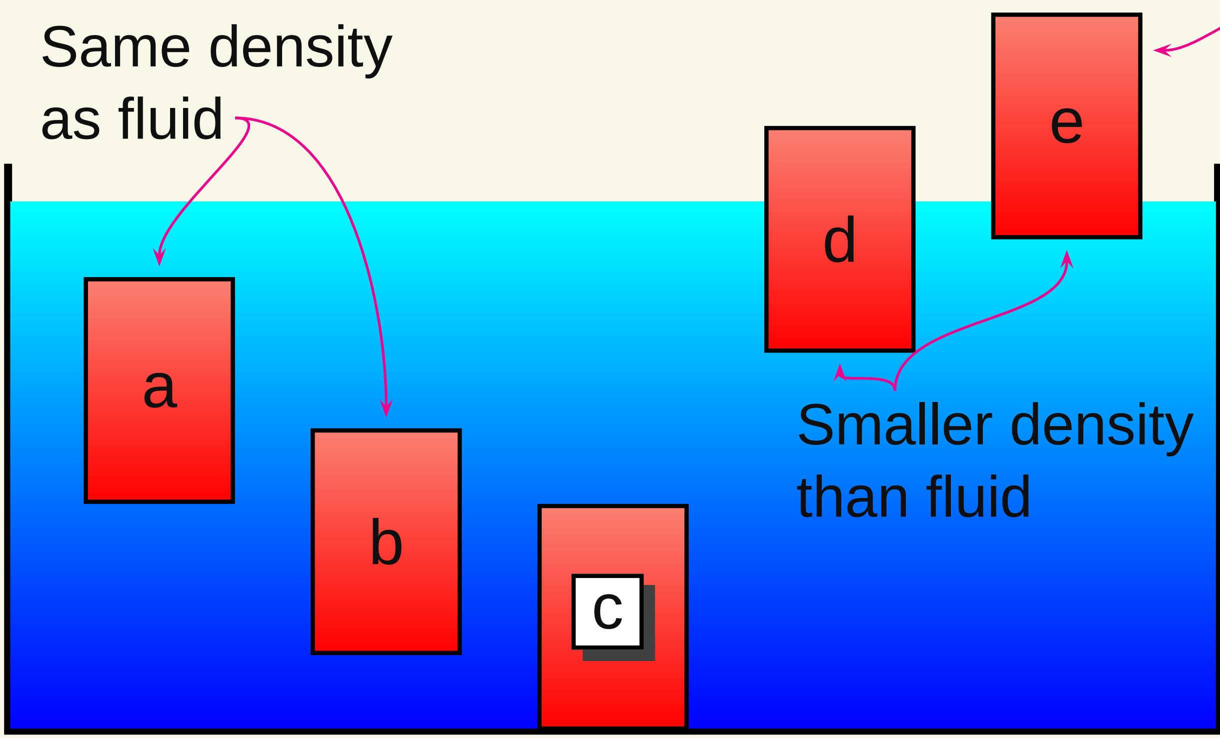

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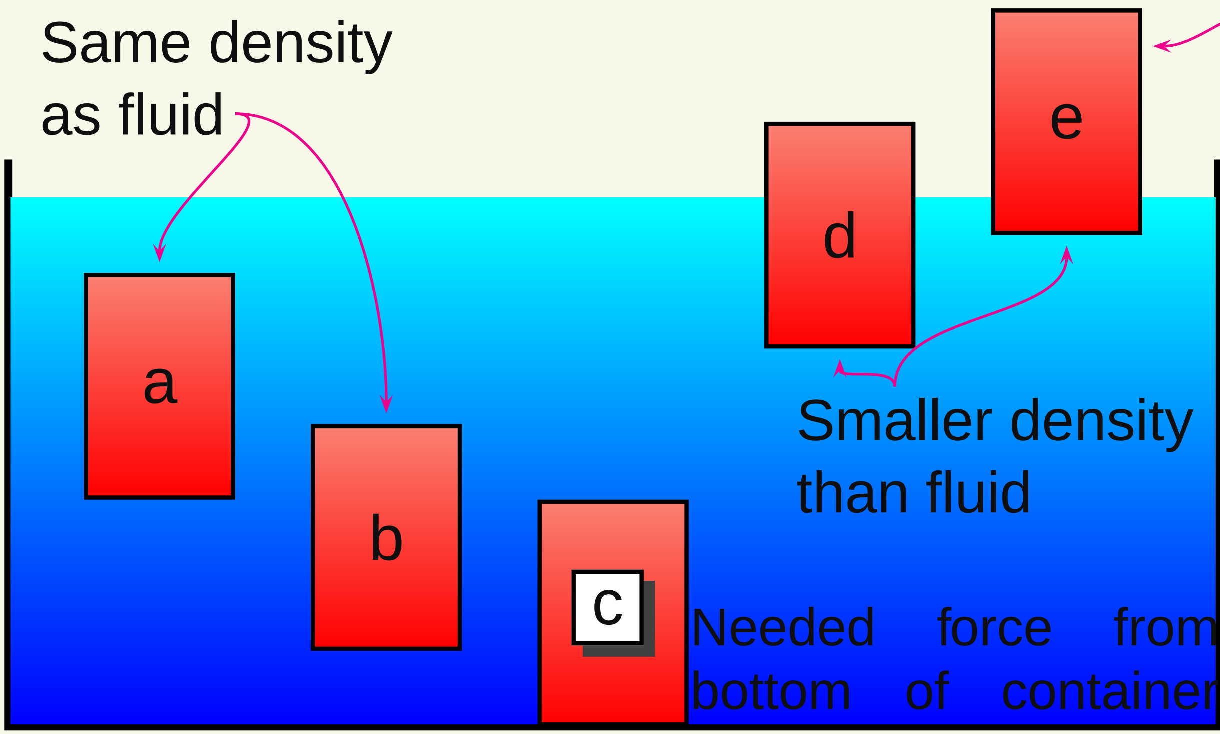

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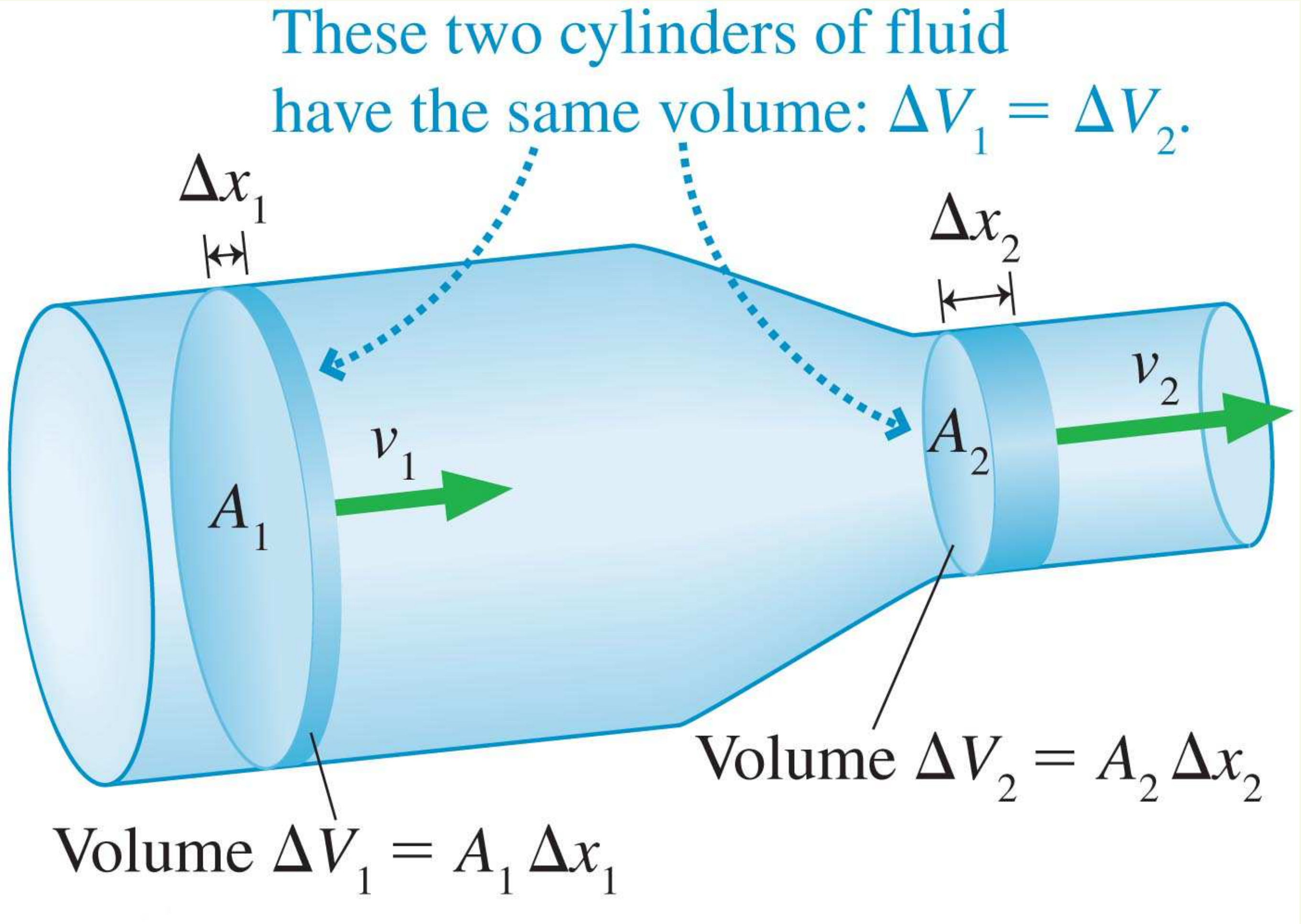

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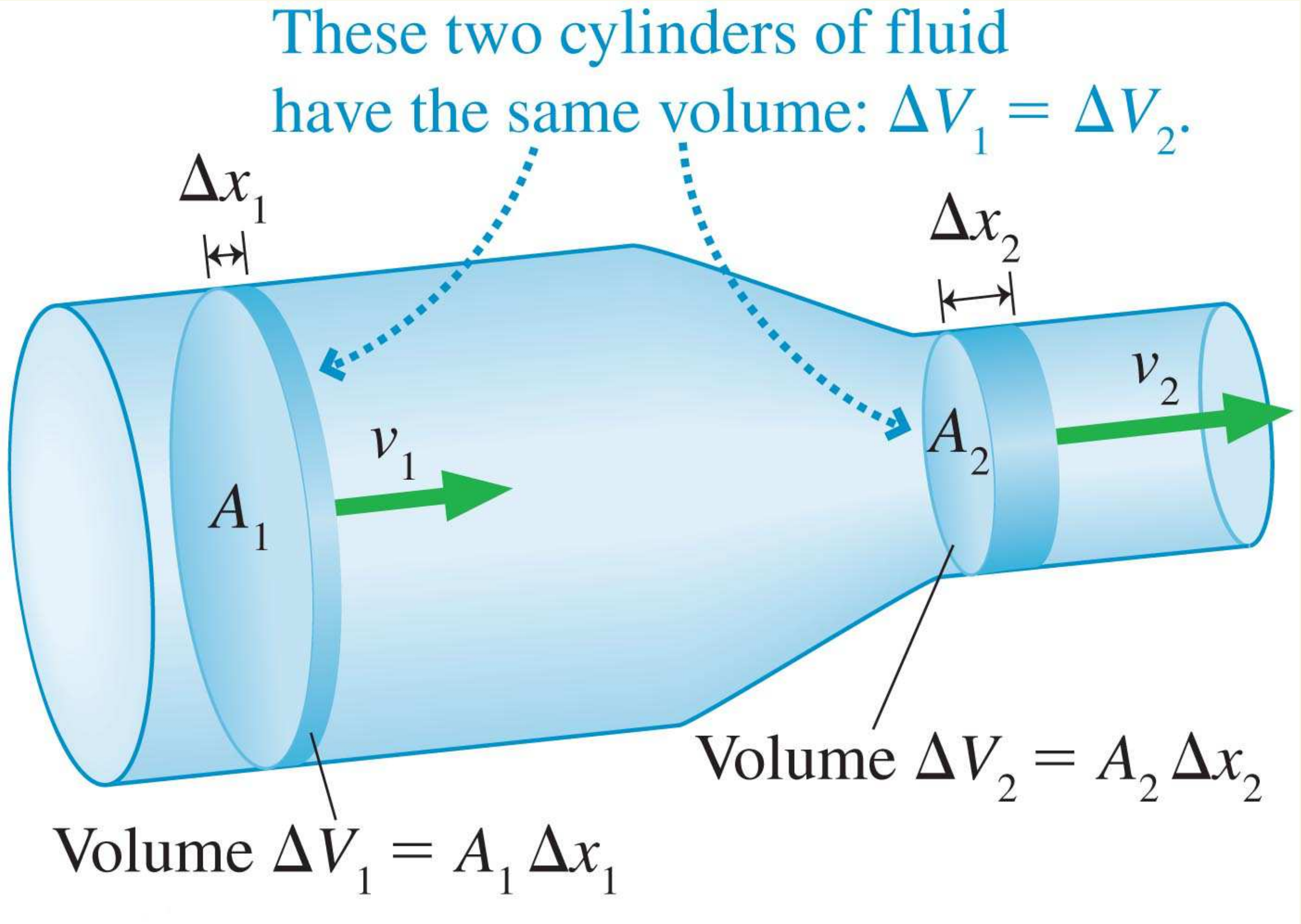

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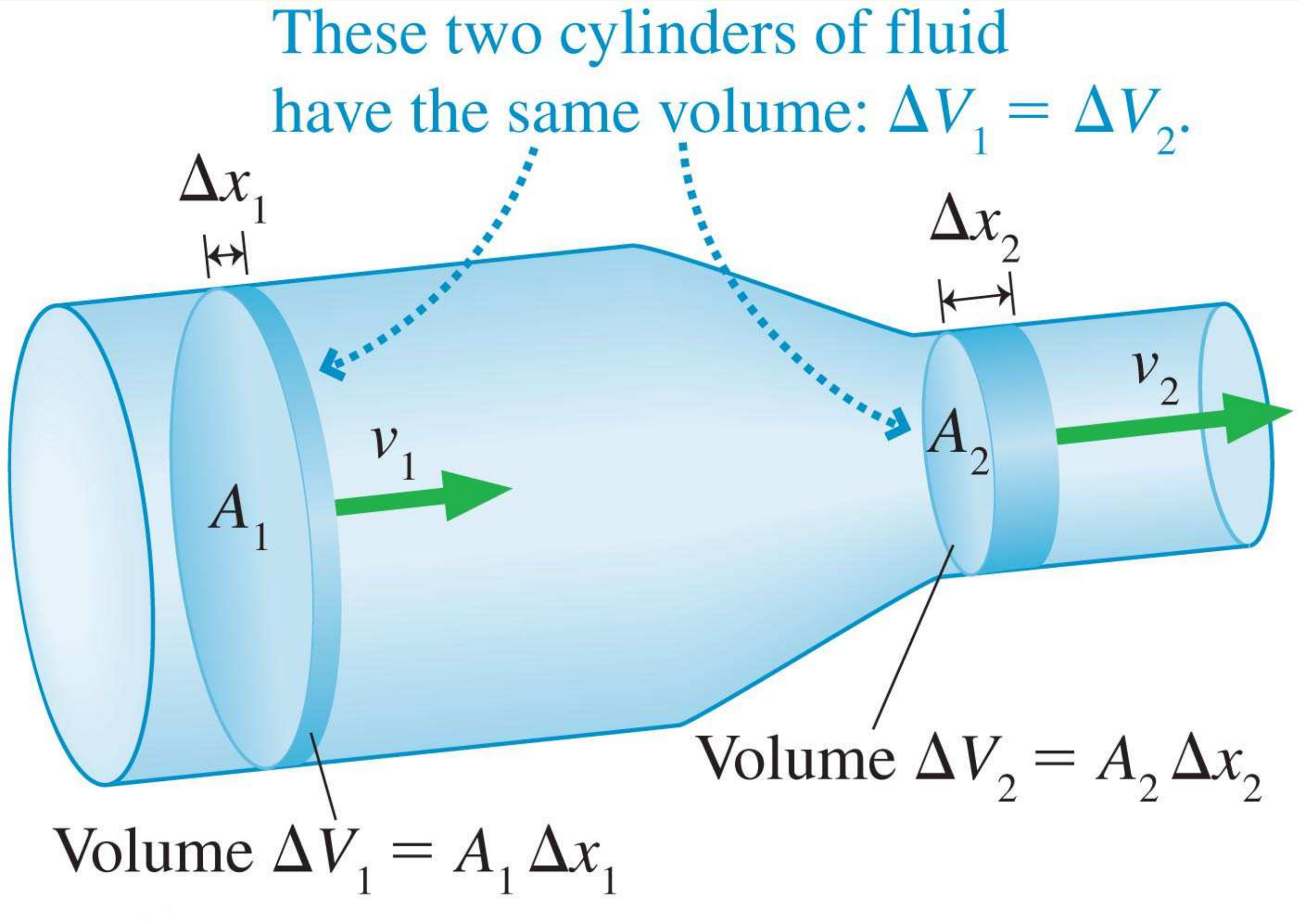

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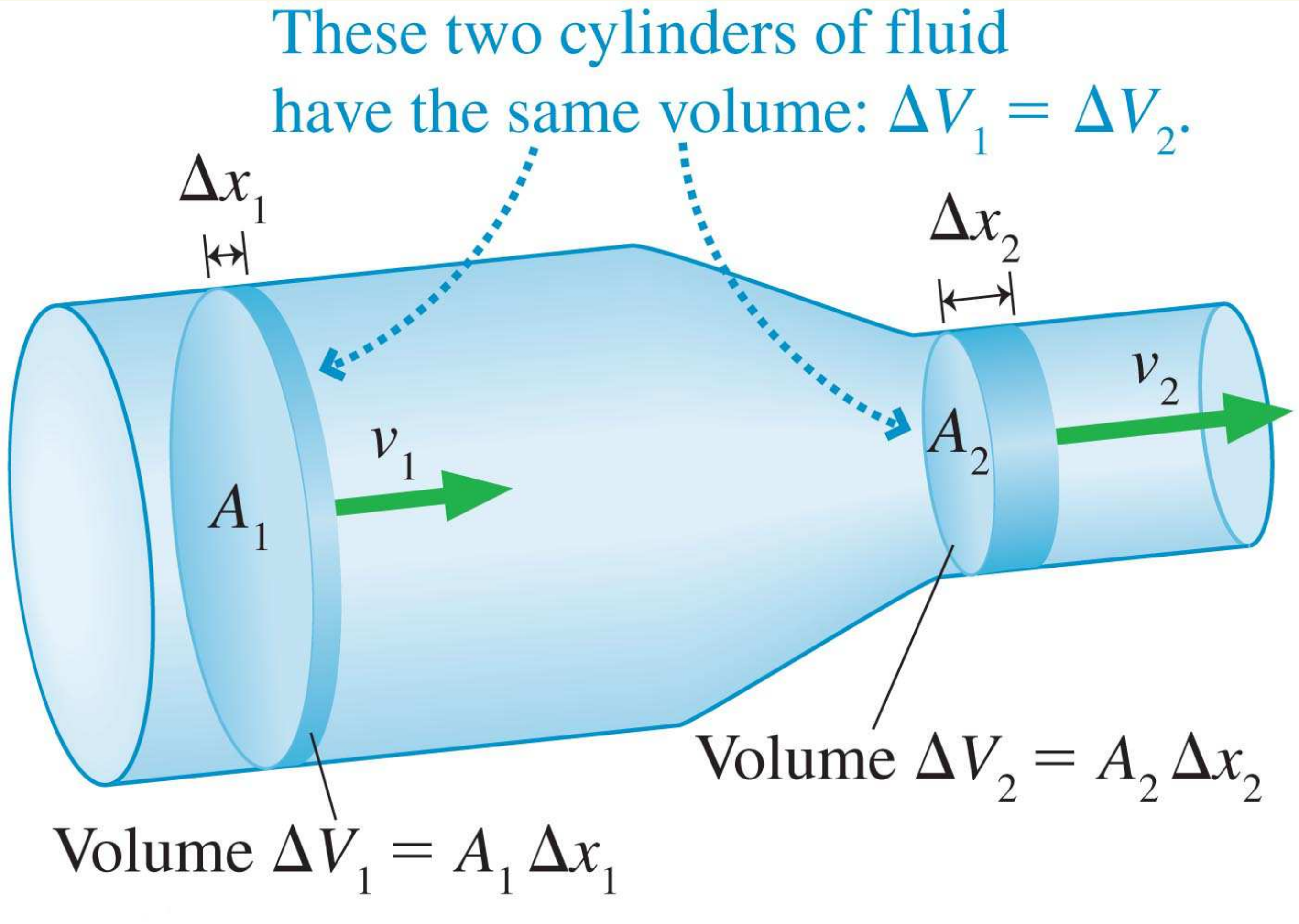

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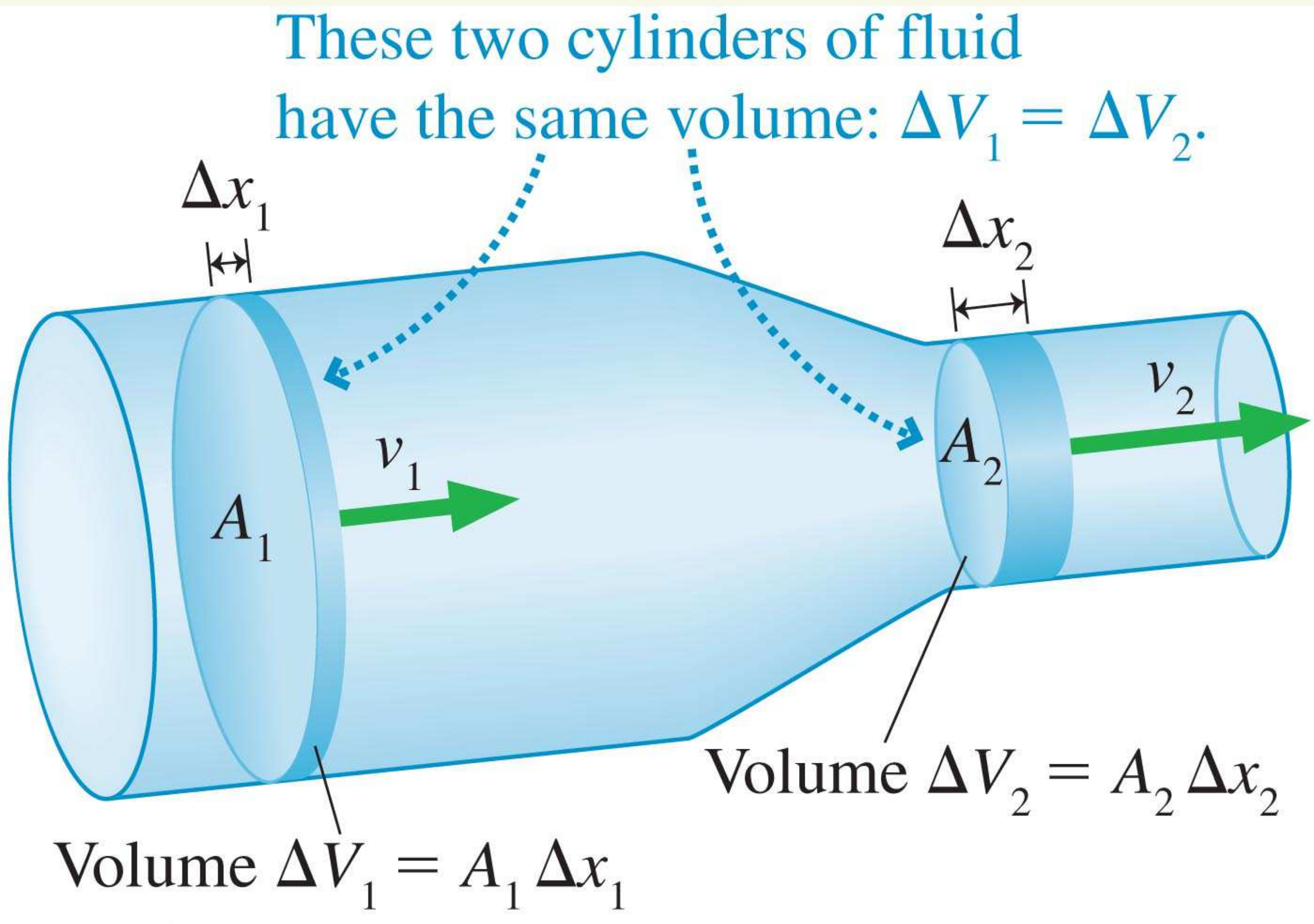

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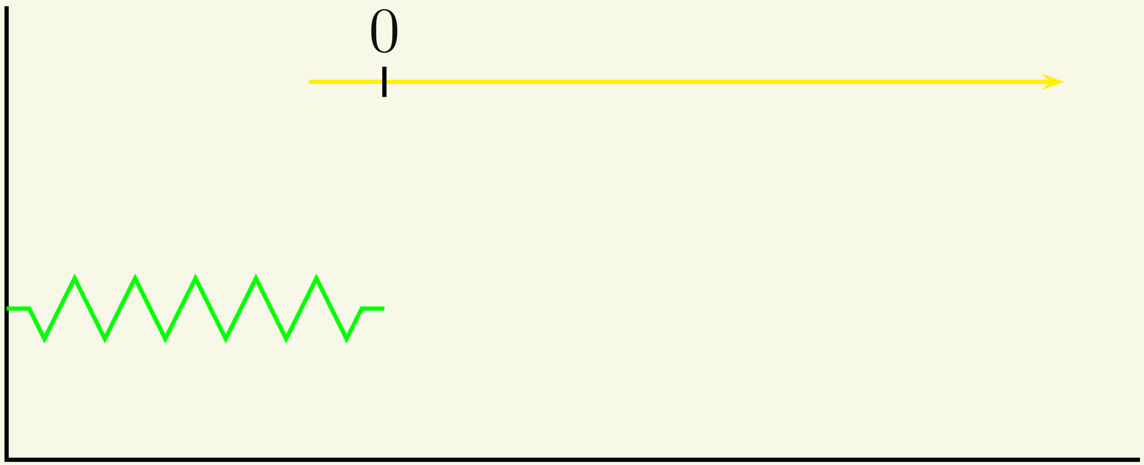

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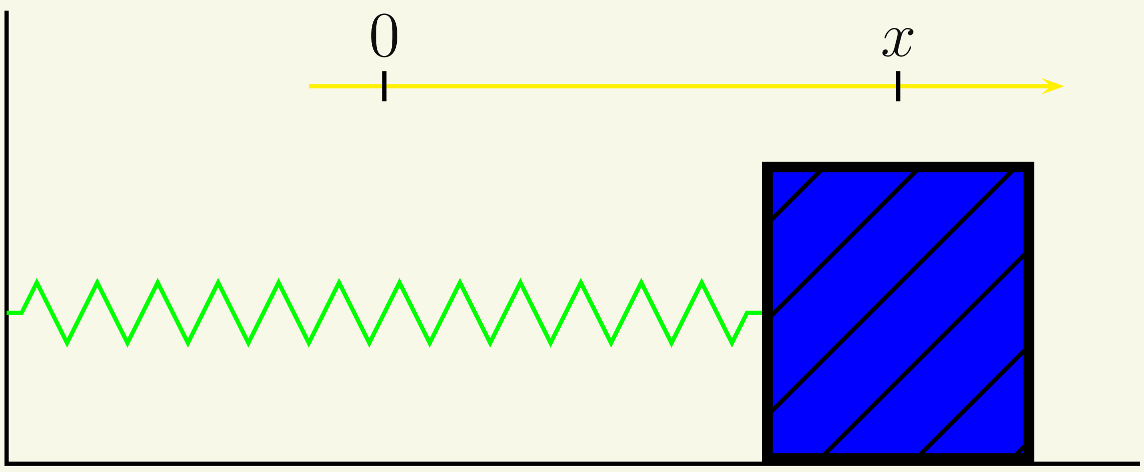

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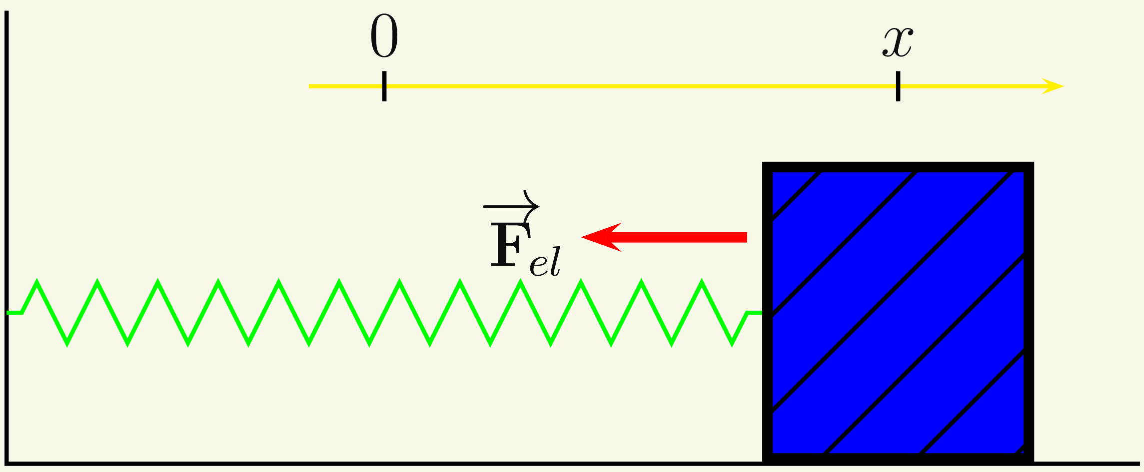

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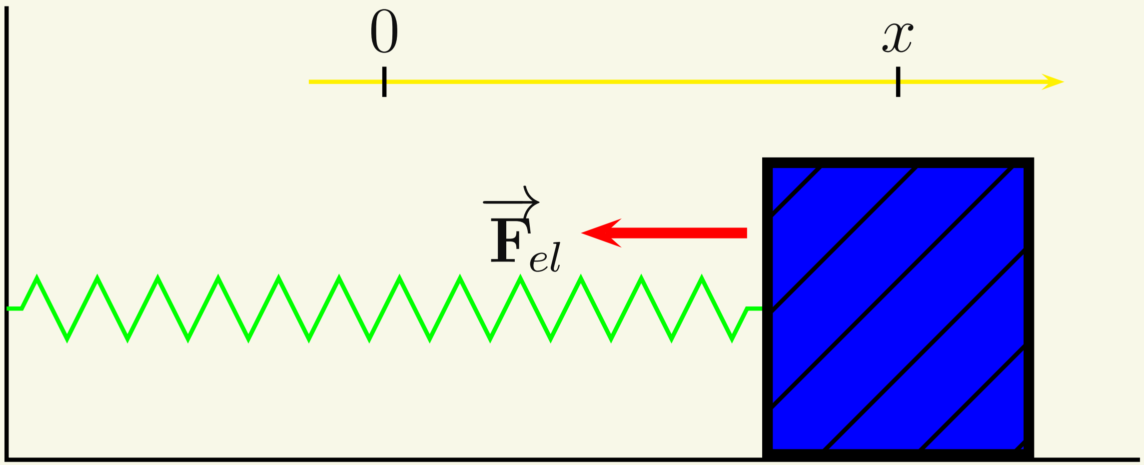

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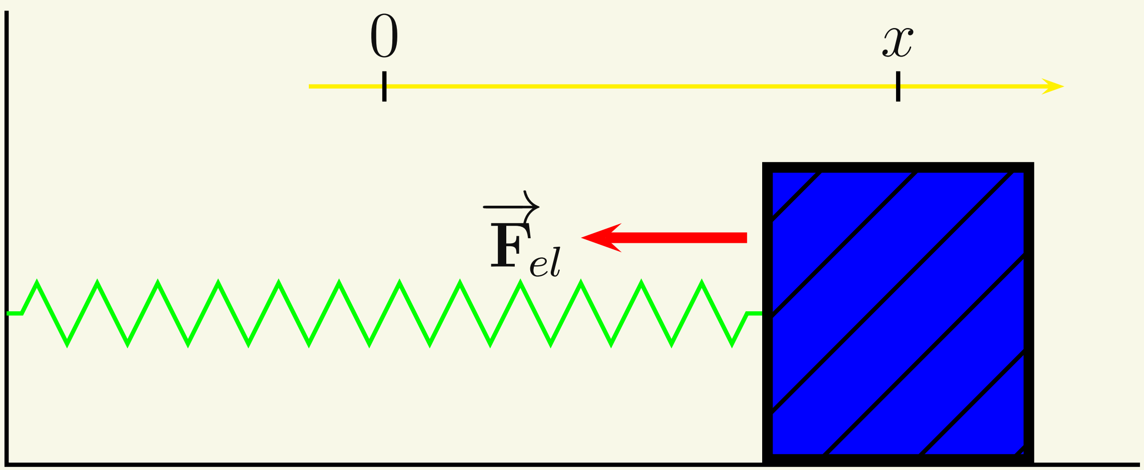

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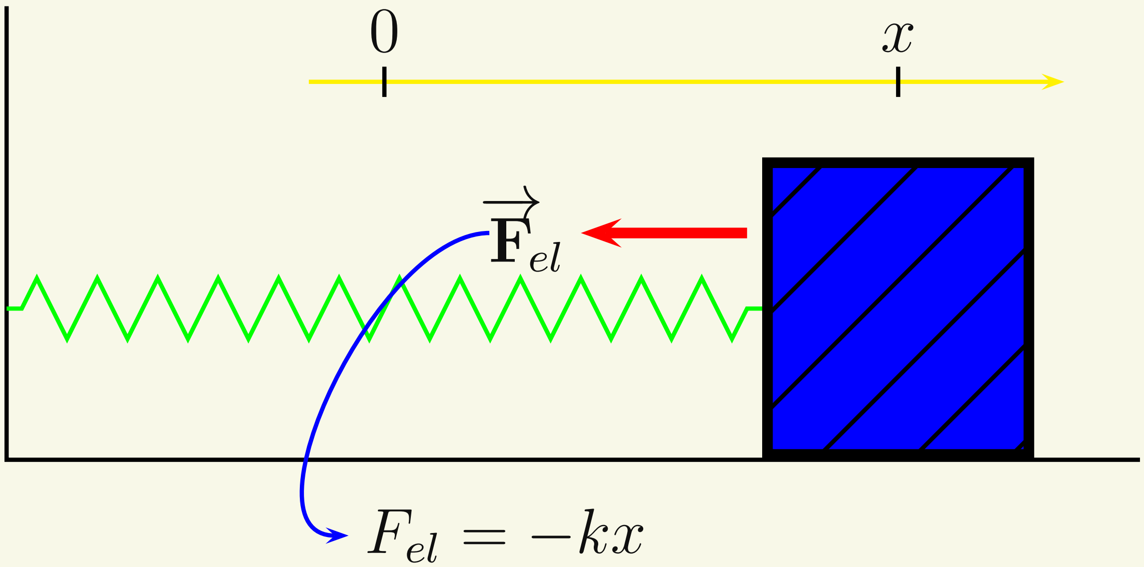

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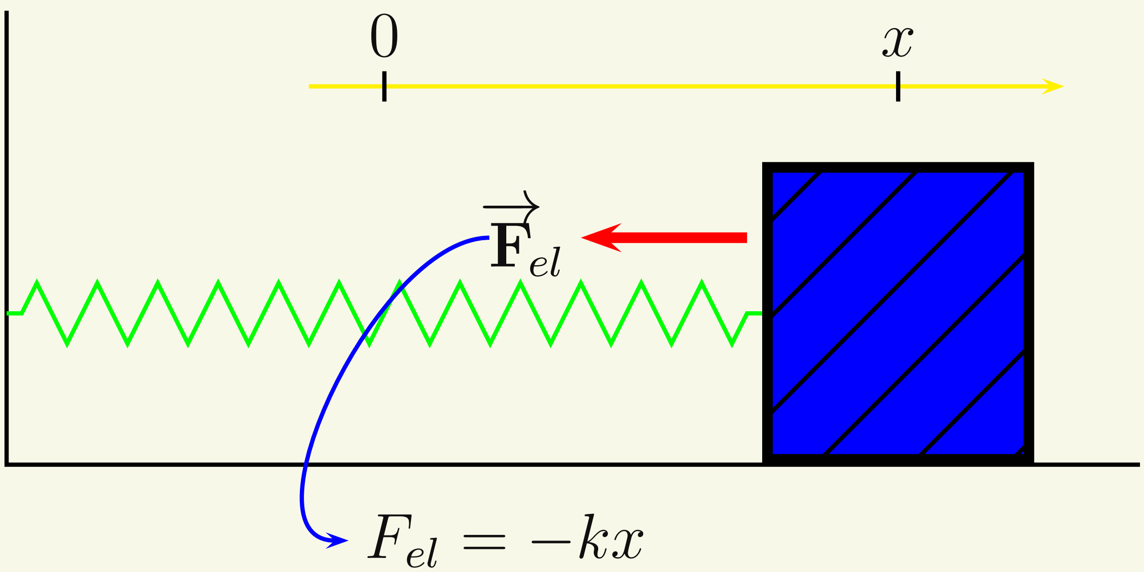

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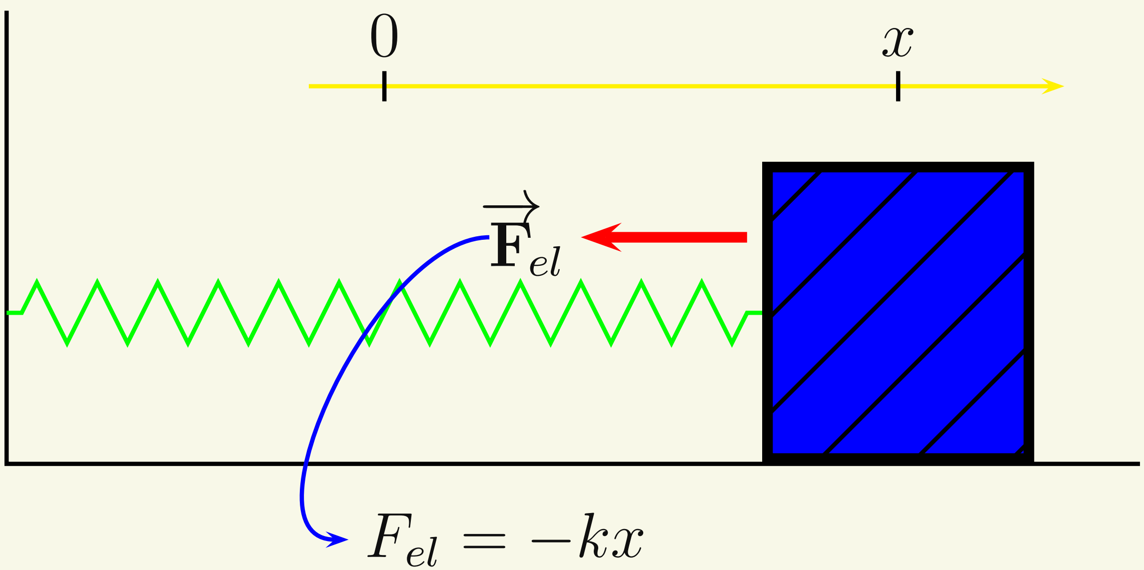

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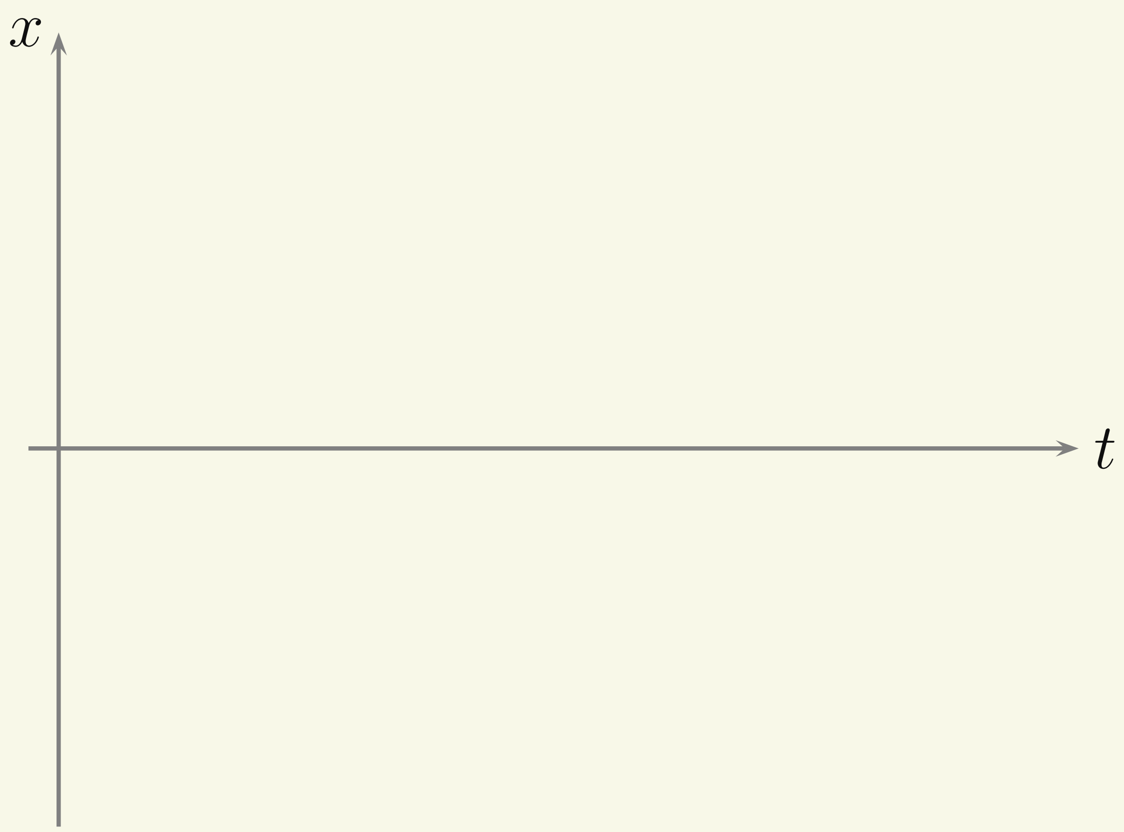

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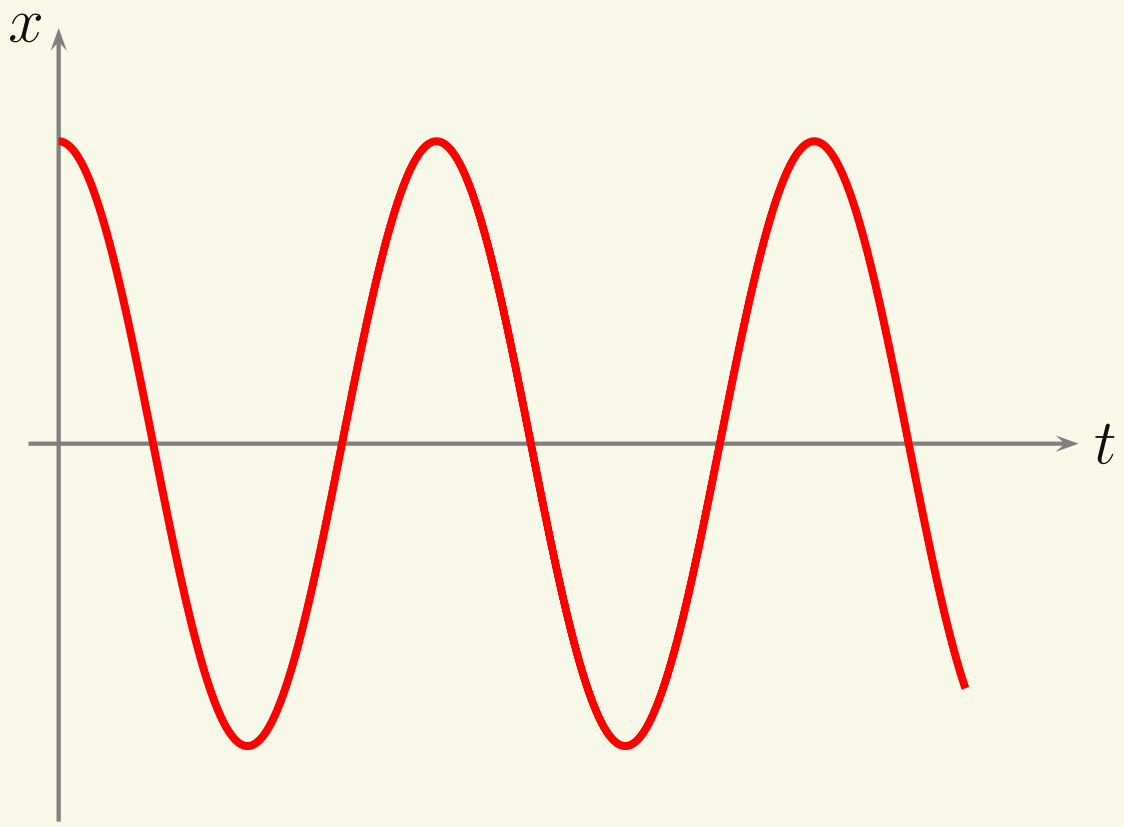

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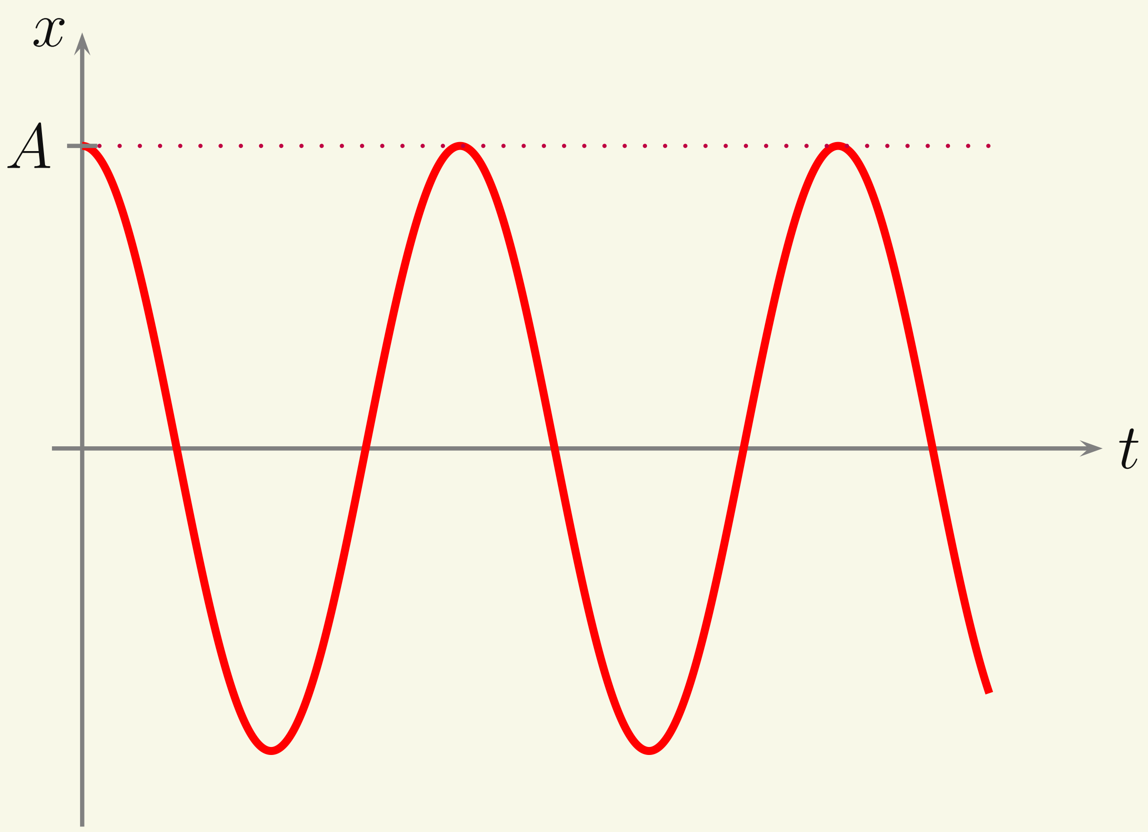

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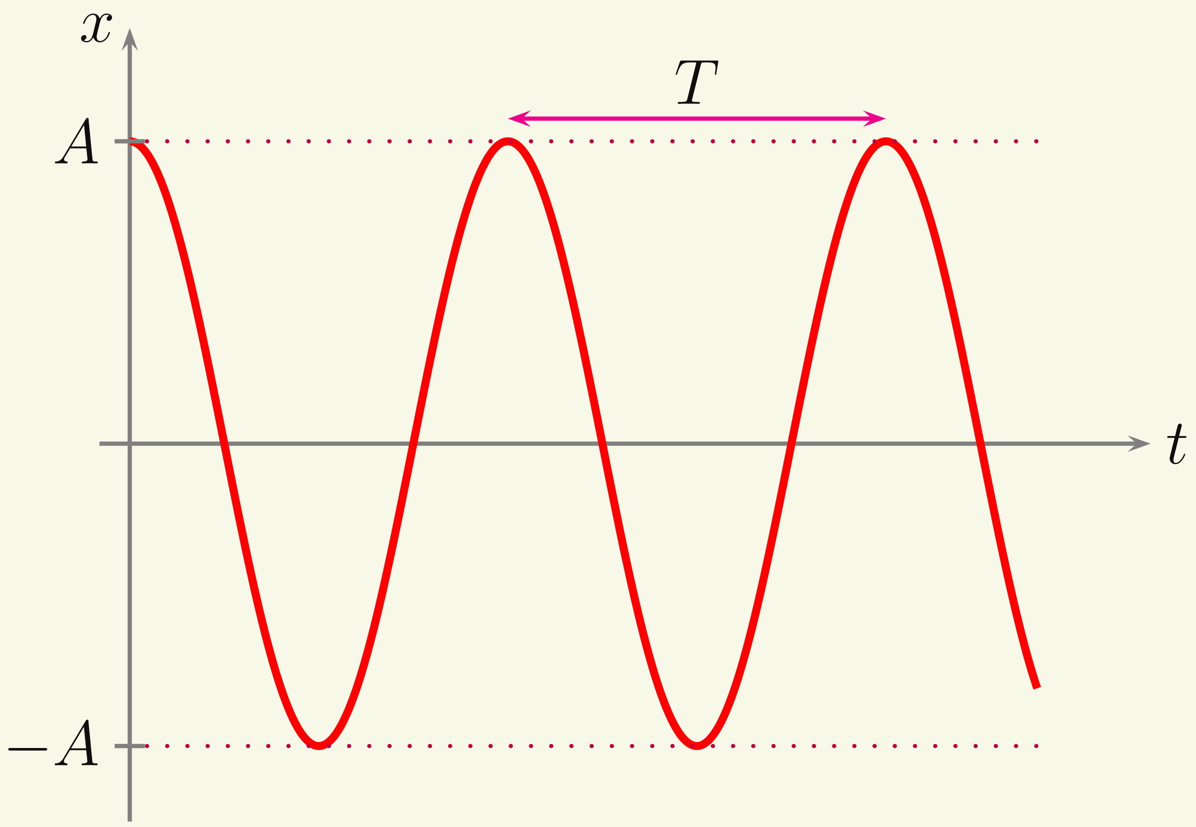

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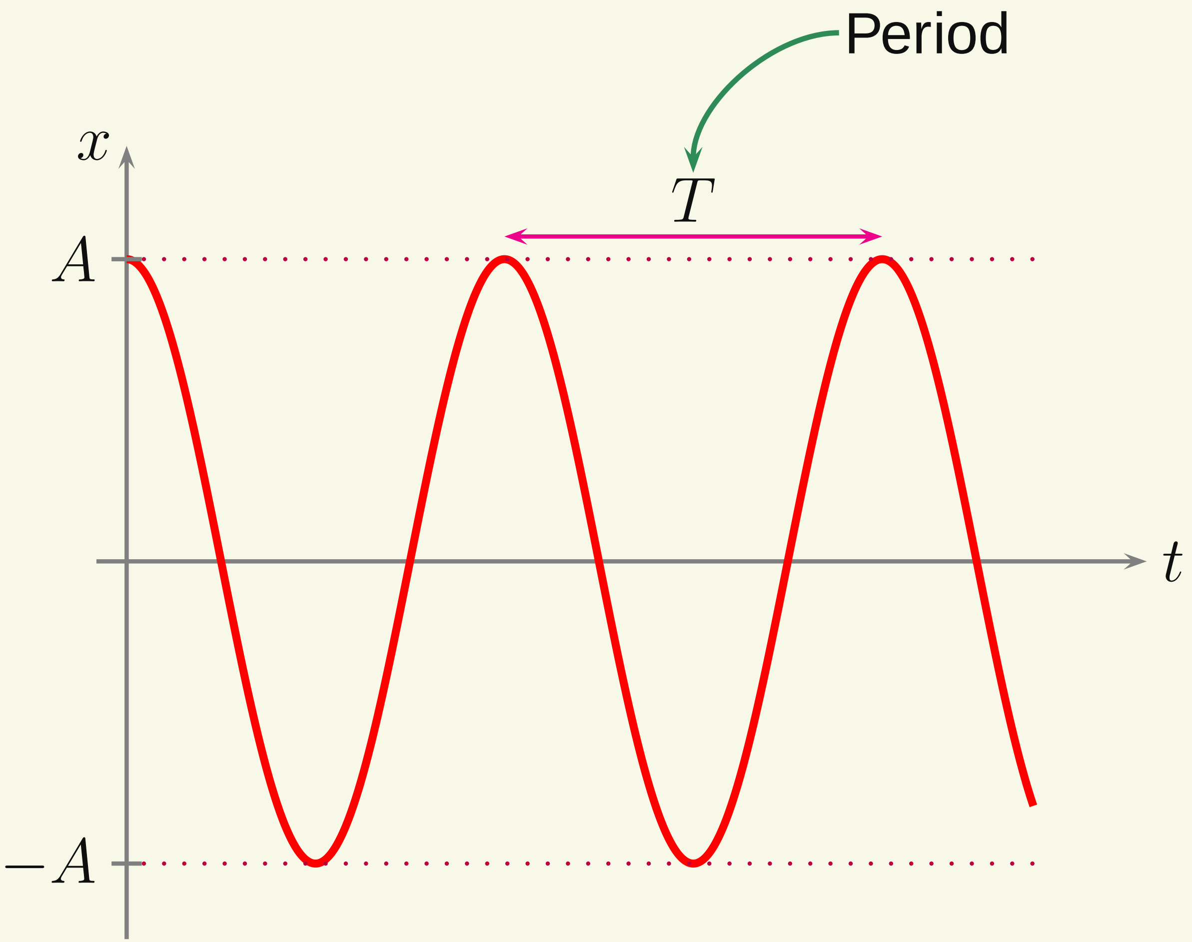

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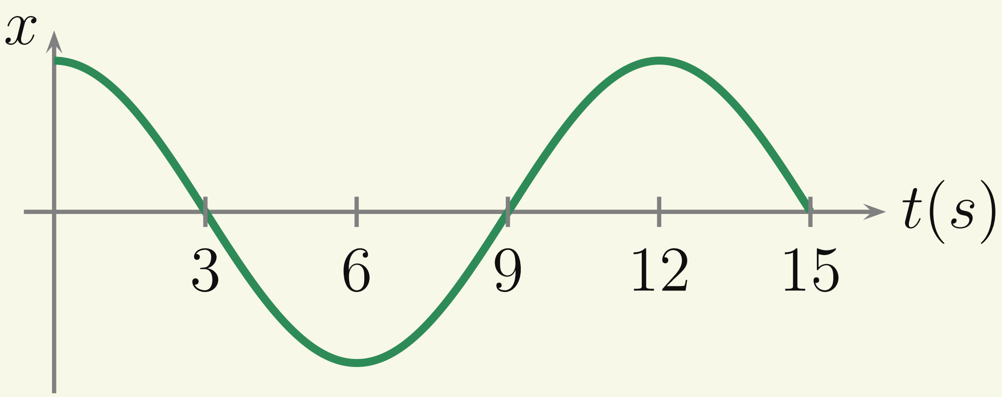

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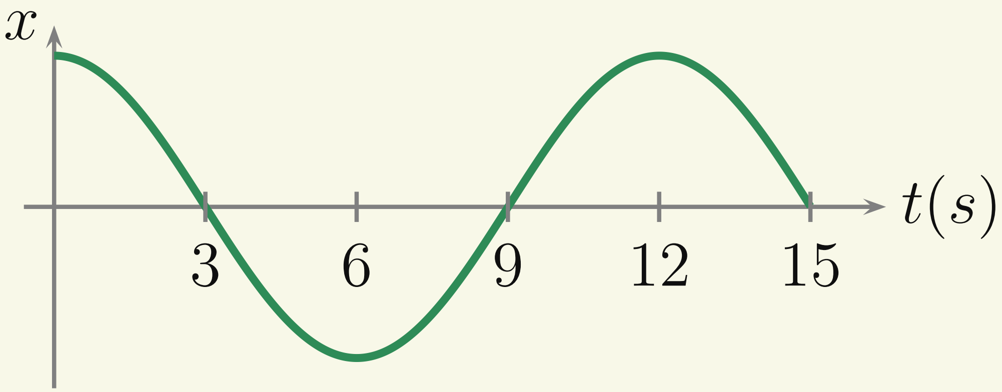

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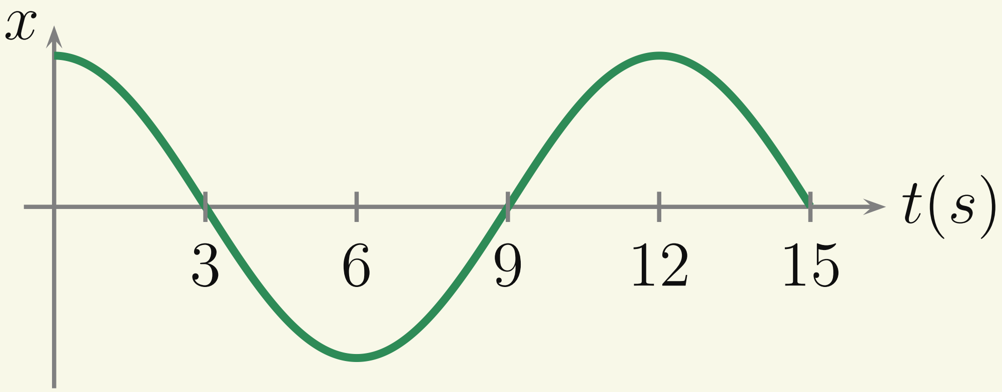

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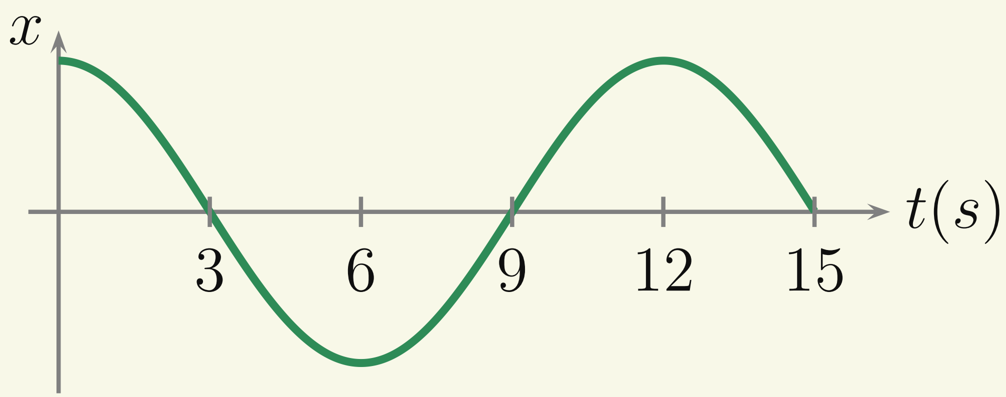

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(b) $3\,s$

(c) $6\,s$

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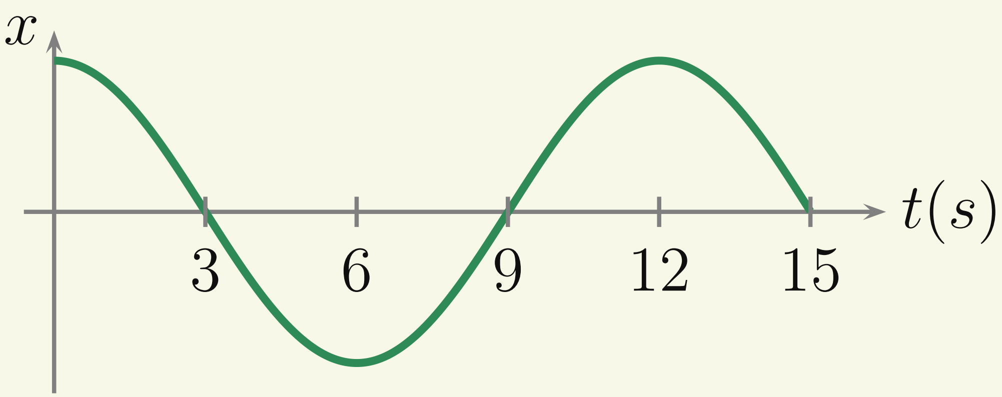

(a) $0\,s$

(b) $3\,s$

(c) $6\,s$

(d) $9\,s$

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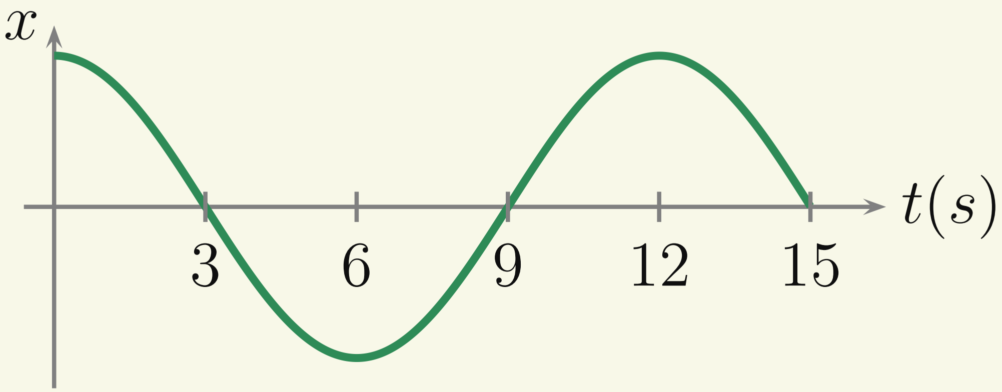

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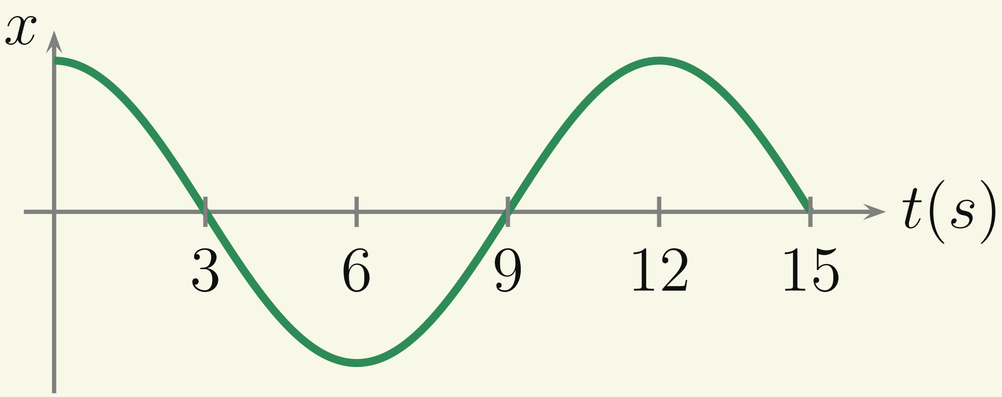

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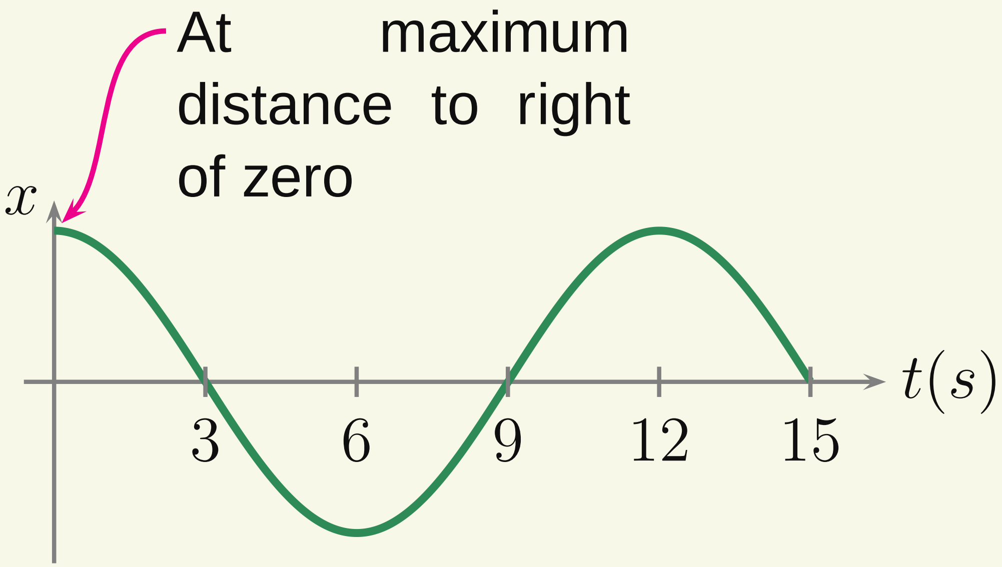

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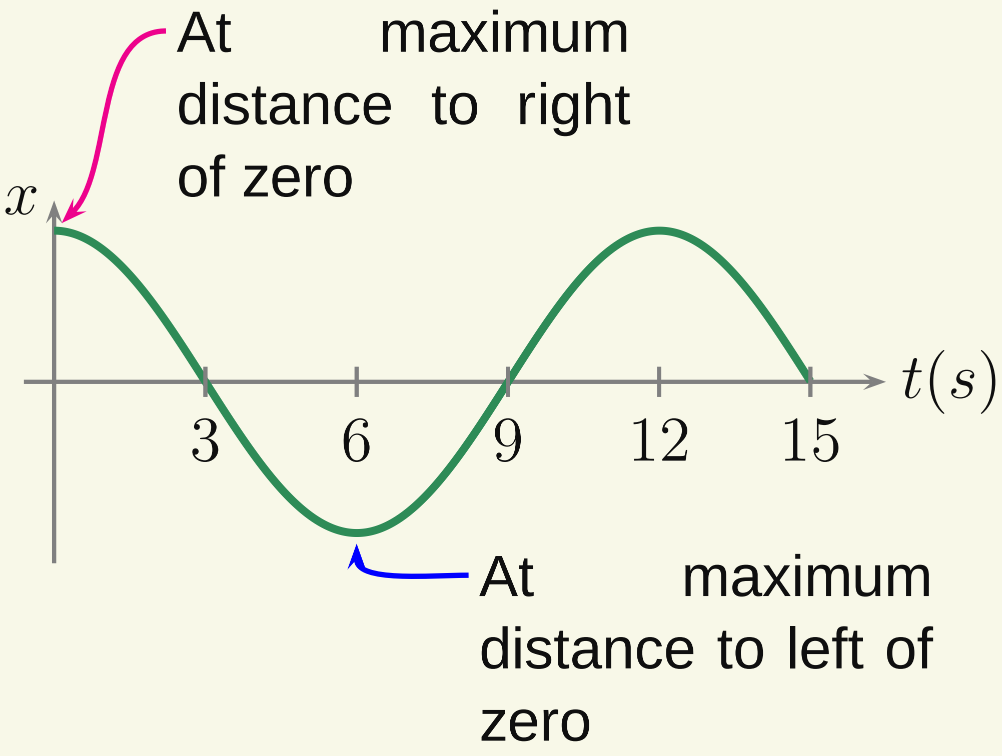

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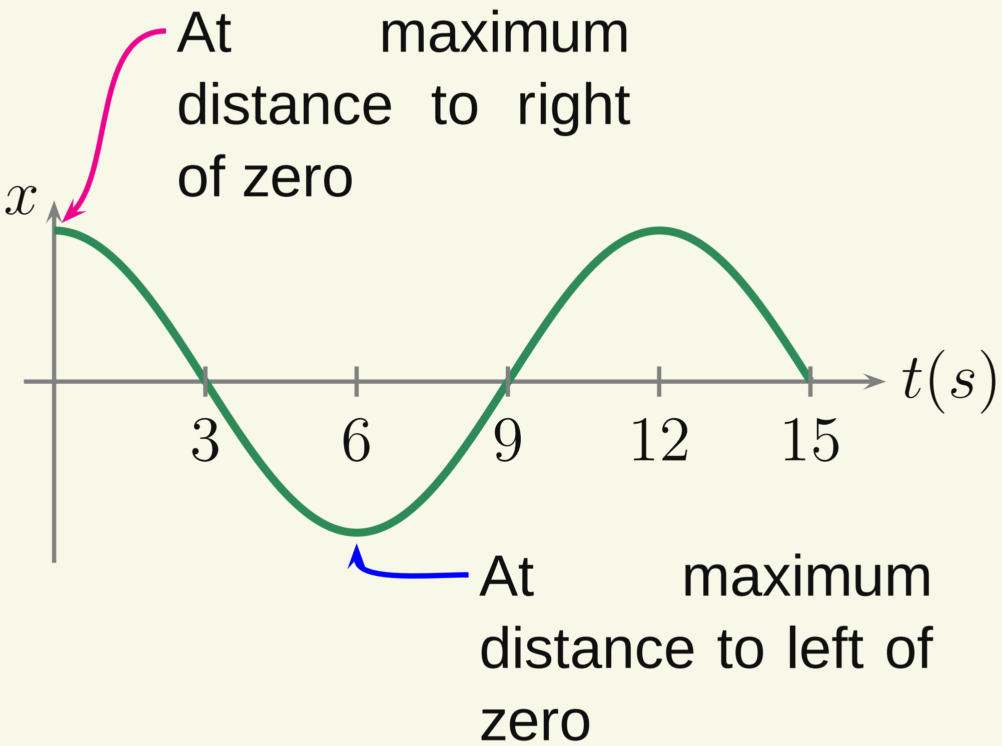

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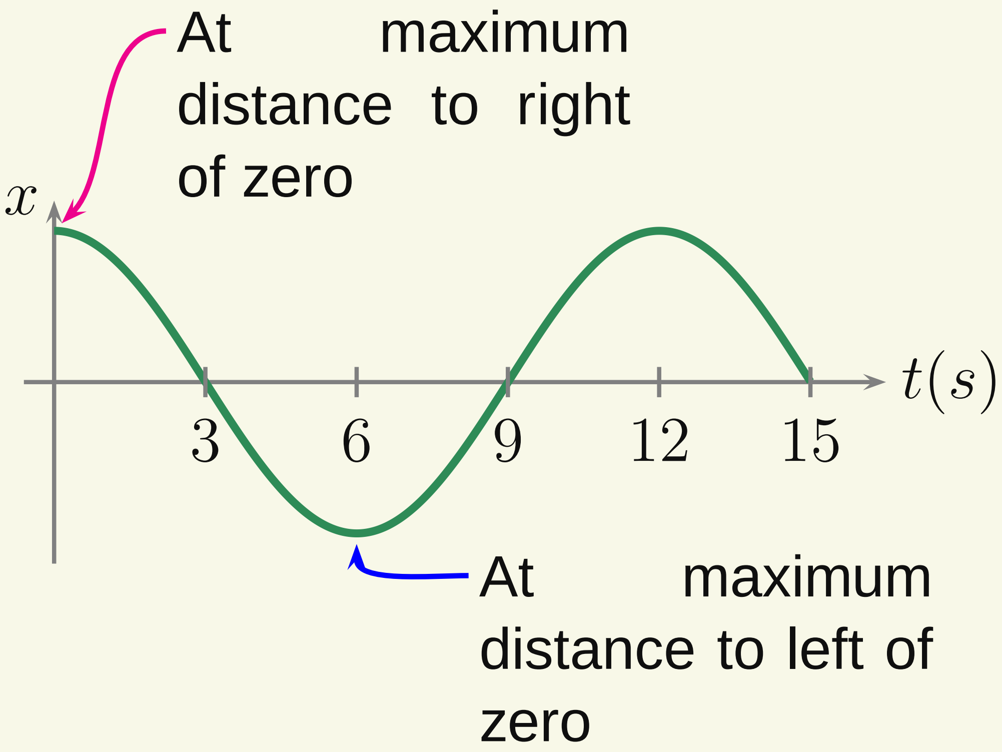

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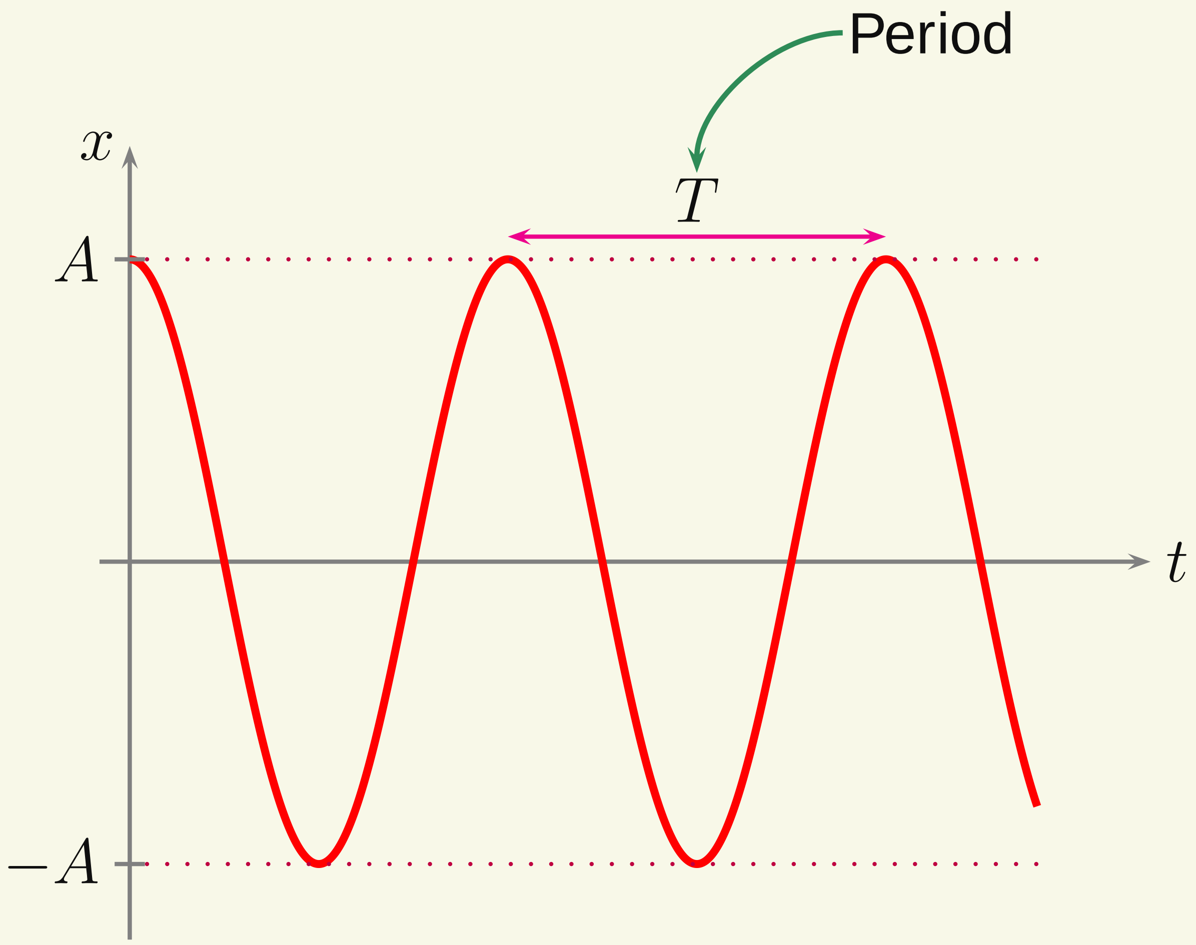
Changing direction at 0 and $6\,s \Rightarrow v = 0 \Rightarrow$ going fastest in the middle

Simple Harmonic Motion II

For a mass started from rest, a distance A from zero, it can be shown that:



$$\boxed{x = A\cos\left(\frac{2\pi t}{T}\right)}$$

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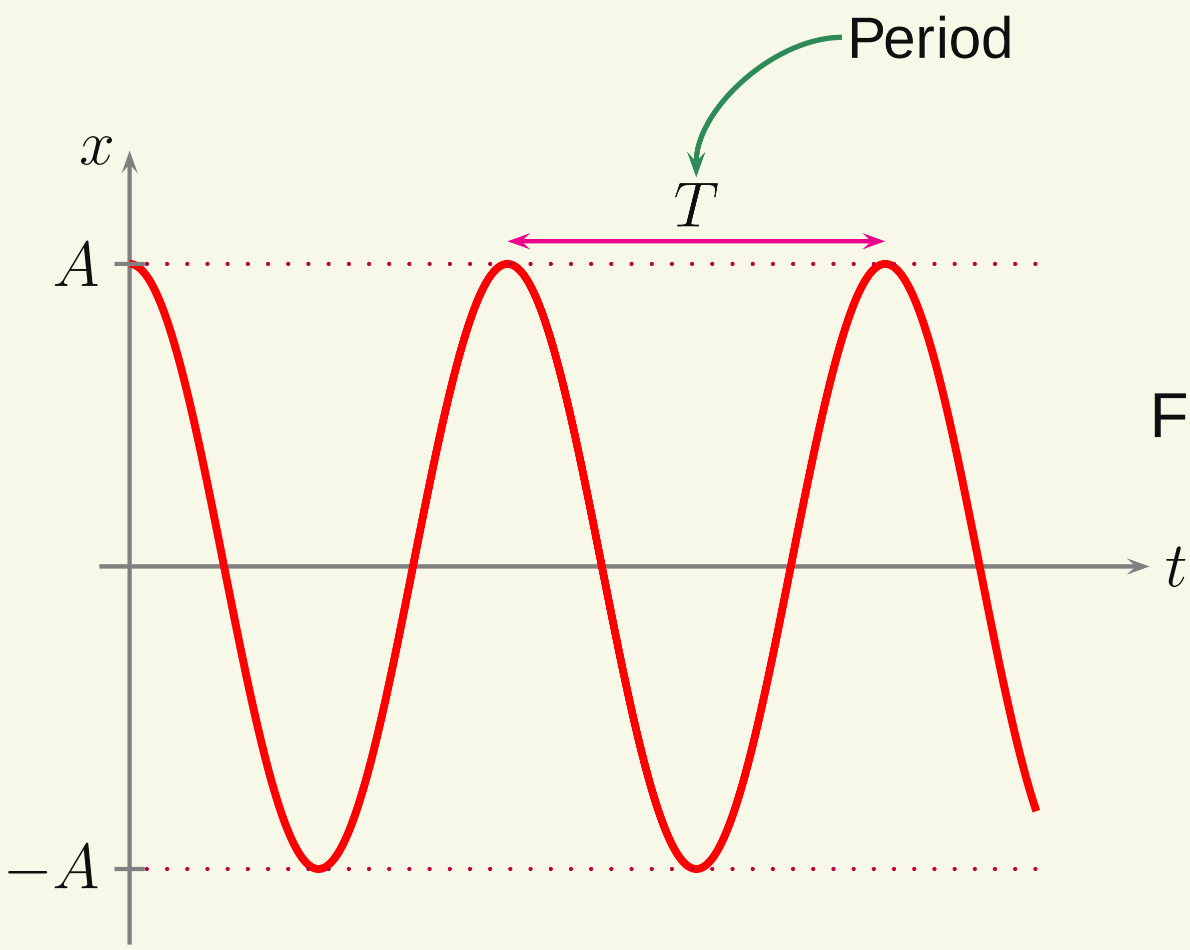

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From Calculus and $a_x = -\frac{k}{m}x$

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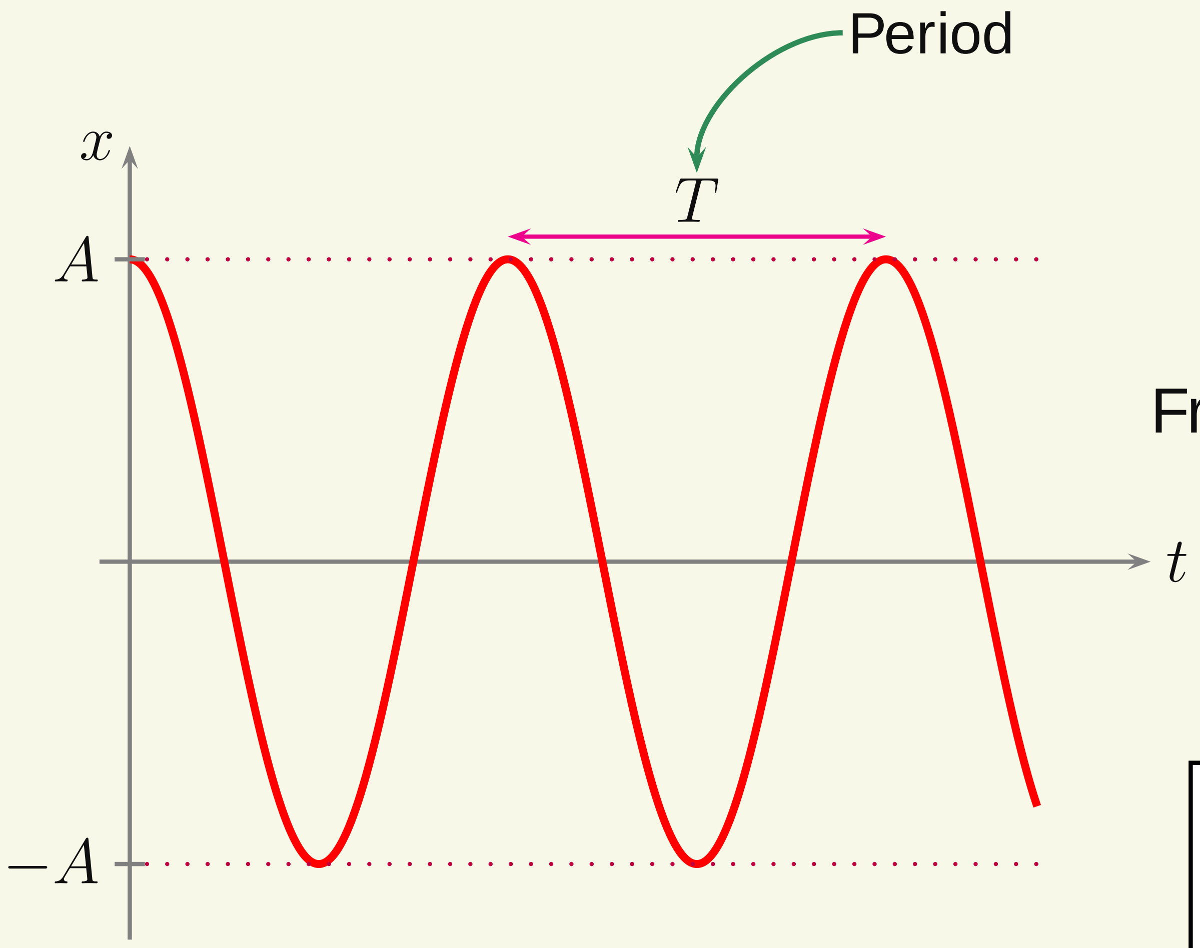

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The mass and the spring constant values determine the period