Balloon in the box demo

If I accelerate the box forward from rest, the balloon
(a) moves backward with respect to the box
(b) moves forward with respect to the box
(c) stays vertical with respect to the box
Balloon in the box demo

If I accelerate the box forward from rest, the balloon moves forward with respect to the box

\[ m_{\text{dis}} = \text{mass of displaced air} < m_{\text{balloon}} \]

The force exerted by the fluid on the balloon = the force exerted by the fluid on the displaced air

\[ = m_{\text{dis}} a \]

Total F on balloon = \( m_{\text{balloon}} \) a = \( m_{\text{dis}} \) a – T

T is the tension force from the string, pulling back so the balloon has to be tilted forward
In a stationary elevator, a block of wood floats at a certain level in a pail of water. If the elevator cab accelerates upward, the block (a) floats higher (b) floats lower (c) floats at the same level (d) I need more information (e) I just don’t understand how to answer
In a stationary elevator, a block of wood floats at a certain level in a pail of water. If the elevator cab accelerates upward, the block floats at the same level

Find $F_B$ by considering the displaced water

$F_B - m_{dis} \cdot g = m_{dis} \cdot a \rightarrow F_B = m_{dis} \cdot (g+a)$

Net force on the block

$F_B - m_b \cdot g = m_b \cdot a \rightarrow m_{dis} \cdot (g+a) = m_b(g+a)$

$m_{dis} = m_b$ same as when $a = 0$

(what about floating blocks on Jupiter with big $g$?)
Physics 272: PRACTICAL

1st HW due 1 February at 11:59PM
Recitations start this week with a quiz from chapter 14

Before class starts:
Demos/questions
Balloon in the box / floating object in elevator
Ask me about prelecture materials
Fluids-Part 2
Fluids in motion:

Fluid flow: tracer particles
The fog machine and smoke ring demo

Fluid element moves with velocity \( \vec{v} \)

describe the fluid flow by \( \vec{v}(t) \) at each point
Fluids in motion:

Steady flow: at each point in the flowing fluid, \( v \) does not change with time

Simple example: fluid of density \( \rho \) flows at velocity \( v \) through a tube of cross-sectional area \( A \)
Fluid of density $\rho$ flows at velocity $v$ through a cylindrical tube of cross-sectional area $A$

Volume flow rate through a cross-sectional surface = volume of fluid that passes through the surface per time
= $(A \Delta x) / \Delta t = A \left( \Delta x / \Delta t \right) = A \, v$
Fluid of density $\rho$ flows at velocity $v$ through a tube of cross-sectional area $A$

Volume flow rate through any cross-section = $A \cdot v$
Equation of continuity

For steady flow, net flow rate into a region must equal the flow rate out of the region.

Volume of fluid does not change with time.

\[ A \cdot v = A \cdot v \]
The figure shows a pipe with steady flow and gives the volume flow rate (in cm³/s) and the direction of flow for all but one section. What are the volume flow rate and the direction of flow for that section?

a) 27 cm³/s in
b) 27 cm³/s out
c) 13 cm³/s in
d) 13 cm³/s out
e) If I picked any of the others I would be guessing
The figure shows a pipe with steady flow and gives the volume flow rate (in cm$^3$/s) and the direction of flow for all but one section. What are the volume flow rate and the direction of flow for that section?

- a) 27 cm$^3$/s in
- b) 27 cm$^3$/s out
- c) 13 cm$^3$/s in
- d) 13 cm$^3$/s out
- e) If I picked any of the others I would be guessing
Let’s apply the equation of continuity to steady flow in a pipe that gets narrow

\[ v_1 A_1 = v_2 A_2 \]

\( A_2 < A_1 \) means \( v_2 > v_1 \) \(\rightarrow\) fluid element speeds up
A water stream narrows as it falls

\[ \rho v^2/2 = \rho v_0^2/2 + \rho gh \]

\( v > v_0 \)
A water stream narrows as it falls

\[ \rho v^2/2 = \rho v_0^2/2 + \rho g h \]

\[ v > v_0 \]

\[ A < A_0 \]

Fluid element speeds up -> flow narrows

Note: you should NOT think of the liquid as a collection of noninteracting particles

Important assumption: density \( \rho \) of liquid does not change
the pressure can be different at different points in the flowing fluid

horizontal flow

\[ v_1 A_1 \quad v_2 A_2 \]

Fluid element of volume V
kinetic energy increase \( \frac{1}{2} \rho V (v_2^2 - v_1^2) \)
work was done on the fluid element
the pressure can be different at different points in the flowing fluid

horizontal flow

\[ v_1 A_1 \quad v_2 A_2 \]

Fluid element of volume V
kinetic energy increase \( \frac{1}{2} \rho V (v_2^2 - v_1^2) \)
work was done on the fluid element

The force that does the work is exerted by the fluid due to a pressure difference
Which of the following statements is true?

(a) Pressure is greater at 1 than at 2
(b) The pressures at 1 and 2 are equal
(c) Pressure is less at 1 than at 2
(d) I would just be guessing
Which of the following statements is true?

(a) Pressure is greater at 1 than at 2
(b) The pressures at 1 and 2 are equal
(c) Pressure is less at 1 than at 2
(d) I would just be guessing
the pressure can be different at different points in the flowing fluid

horizontal flow

\[ \mathbf{v}_1 \, A_1 \quad \mathbf{v}_2 \, A_2 \]

Fluid element of volume \( V \)
kinetic energy increase \( \frac{1}{2} \rho \, V \, (v_2^2 - v_1^2) \)

\[ P_2 = P_1 - \frac{1}{2} \rho \, (v_2^2 - v_1^2) \]
\[ P_2 + \frac{1}{2} \rho \, v_2^2 = P_1 + \frac{1}{2} \rho \, v_1^2 \]
Bernoulli equation for horizontal flow: \( v \uparrow \rightarrow P \downarrow \)
LIGHT BULB DEMO
If I blow between the two bulbs, then

(a) Nothing happens
(b) they move apart
(c) they move together
(d) I have no idea
Bernoulli Ball

Air further from center axis moves slower pressure is higher – pushes ball back
Funnel Ball

Air flow over top of ball is faster than below
Upward force balances weight
Let’s think about water flowing upward in a pipe at speed \( v \)

Follow a fluid element of mass \( m \)
Kinetic energy stays the same
Potential energy increases by \( m \, g \, h \)

Work is being done on the fluid element
Force exerted by fluid: pressure difference
Pressure below is greater than pressure above

\[
F \, h = m \, g \, h = \rho \, V \, g \, h \\
(F = \rho \, V \, g)/A \\
P_{\text{bott}} - P_{\text{top}} = \rho \, (y_{\text{top}} - y_{\text{bott}}) \, g
\]

\( P + \rho \, g \, y \) is the same at all points in the flow
Bernoulli’s equation – the pressure is different at different points in the flow

Flow up and down hills
Kinetic energy + potential energy changes due to pressure difference

\[
\frac{1}{2} \rho v_1^2 + \rho g h_1 + P_1 = \frac{1}{2} \rho v_2^2 + \rho g h_2 + P_2
\]

If \( v \) is zero, get the pressure/height relation from before

\[
P_2 = P_1 - \rho g (y_2 - y_1)
\]