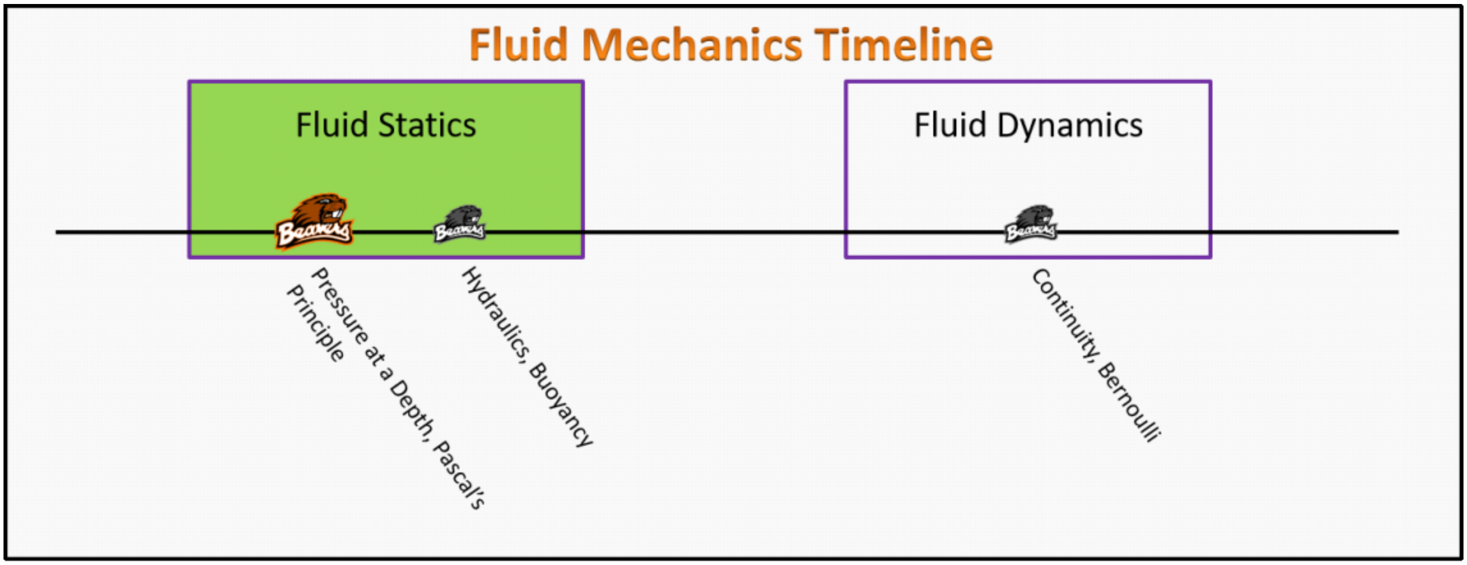
(FS.L1.123) Template for Boxsand

Thursday, March 29, 2018 8:34 PM

Fluid Statics

Familiarize Stage (FS.L1.1)

Lecture 1
Pressure at a Depth, Pascal's Principle

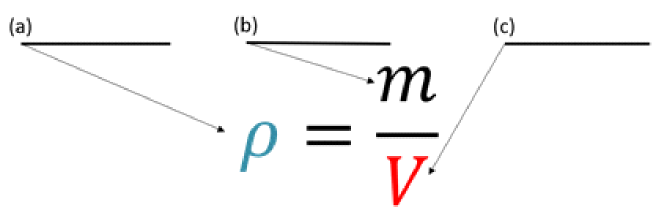


FS.L1.1-01

Description: Infographic quiz density - label matching

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Match each term in the equation with the correct description from the following list. (1) Volume, (2) Mass, (3) Mass density



FS.L1.1-02

Description: Proportional reasoning with density

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider a square block of mass M. If a second block has sides 3 times as long but the same mass, by what factor does it change the block's density?

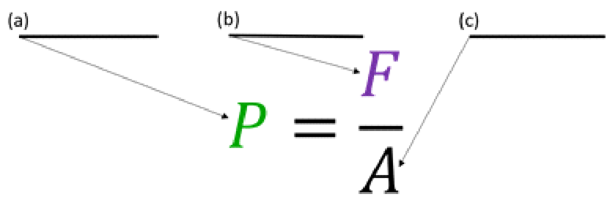
(1) 1/27
(2) 1/9
(3) 1/6
(4) 1/3
(5) 3
(6) 6
(7) 9
(8) 27

FS.L1.1-03

Description: Infographic quiz pressure - label matching

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: Match each term in the equation with the correct description from the following list. (1) Force, (2) Area, (3) Pressure



FS.L1.1-04

Description: Pressure units

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: What is the SI unit for pressure?

(1) a Pascal, or N/m^3
(2) a Coulomb
(3) a Newton
(4) a Pascal, or N/m^2

FS.L1.1-05

Description: Proportional reasoning with pressure

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider a square block of mass M resting on a table creating a pressure P on the table's surface. If a second block has sides 3 times as long but the same mass, by what factor does it change the pressure on the table?

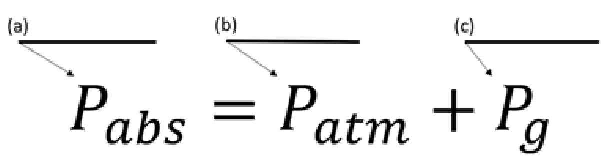
(1) 1/9
(2) 1/6
(3) 1/3
(4) 1
(5) 3
(6) 6
(7) 9

FS.L1.1-06

Description: Infographic quiz absolute pressure - label matching

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Match each term in the equation with the correct description from the following list. (1) Atmospheric pressure, (2) Absolute pressure, (3) Gauge pressure



FS.L1.1-07

Description: Infographic quiz - label matching

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Match each term in the equation with the correct description from the following list. (1) Fluid density, (2) Gravity, (3) Depth, (4) Pressure at a depth, (5) Pressure above the top of the fluid

(a) ________ (b) ________ (c) ________

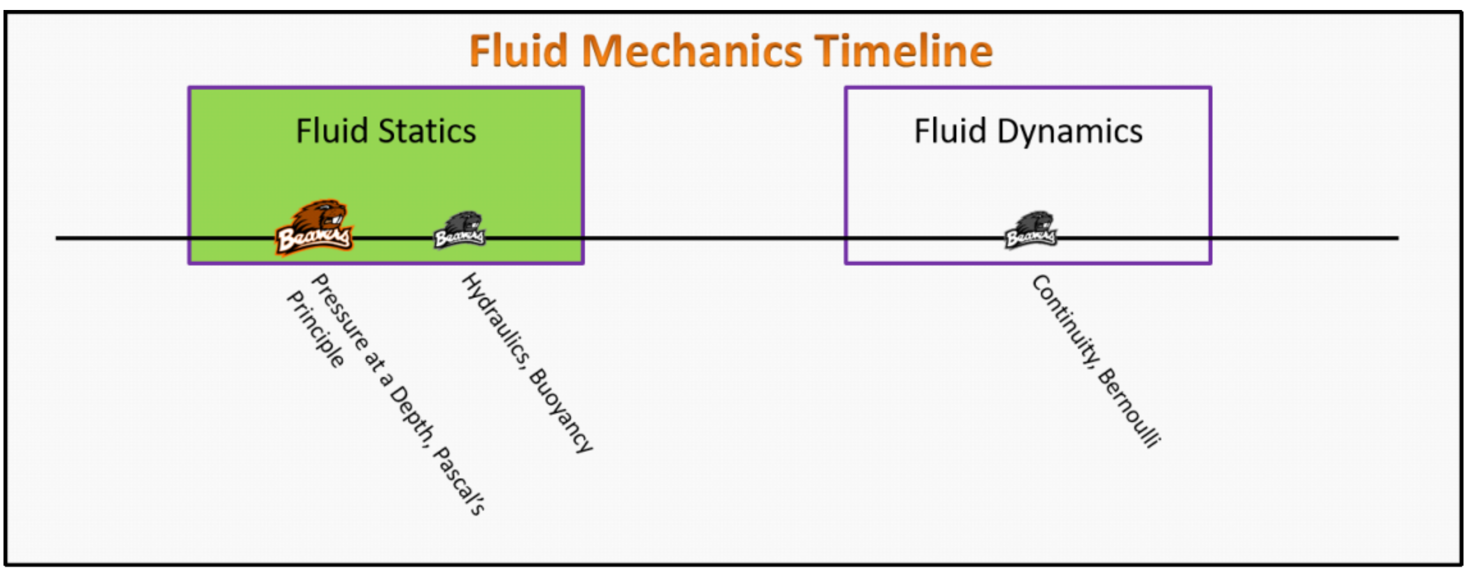
$$P_i = P_o + \rho_f g d$$

(d) ________ (e) ________

Fluid Statics

Foundation Stage (FS.L1.2)

Lecture 1
Pressure at a Depth, Pascal's Principle



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos (Density , Pressure , Hydrostatics)
- **Knight** (College Physics : A strategic approach 3rd) :: 13.1 ; 13.2 ; 13.3

- ***Knight** (Physics for Scientists and Engineers 4th) :: 14.1 ; 14.2 ; 14.3
- **Giancoli** (Physics Principles with Applications 7th) :: 10-1 ; 10-2 ; 10-3 ; 10-4 ; 10-5 ; 10-6

Warm up

FS.L1.2-01:

Description: Describe what pressure means in terms of forces and areas.

Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: Suppose you measure a 10 N force exerted by an object resting on a table. You then divide this force by the contact area between the object and the table; you measured 2 m^2. The calculated number 10N/2m^2 is called pressure, but how do you interpret the number 10/2? Basically what does this number mean to you, or what does the number tell you?

Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Mass density
- Pressure
- Atmospheric pressure
- Gauge pressure
- Absolute pressure (a.k.a true pressure, or actual pressure)
- Hydrostatic pressure (a.k.a pressure at a depth)
- Force associated with pressure difference
- Pascal's principle

Key Equations

$\mathbf{P_1 = P_o + \rho_f\, g\, d}$	$\mathbf{P_{abs} = P_{atm} + P_g}$

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Definition of Pressure

FS.L1.2-02:

Problem Statement: A rectangular block is at rest on a table. Three faces of the block are labeled **A**, **B**, and **C**. The dimensions of each face are shown in the table below.

Face	Dimensions (L x W)
A	3 cm x 4 cm
B	2 cm x 3 cm
C	2 cm x 4 cm

(a) Rank the pressure exerted by the block on the table when it is resting on each labeled side.

(b) Calculate the largest pressure (in Pascals) of the block on the table if the block has a density of 8,050 kg/m^3.

FS.L1.2-03:

Problem Statement: As a lab coordinator, you receive a report from the engineers building your lab that they will have -10 PSI at one of the stations.

(a) Is this the actual pressure at the station? Support your answer with an explanation.

(1) Yes
(2) No

(3) Unable to determine with given information.

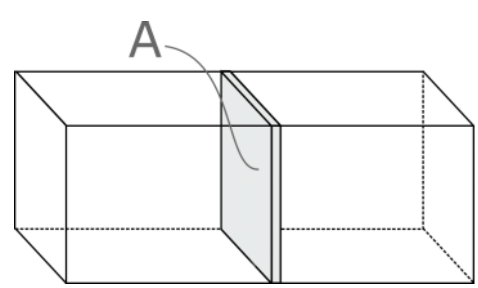
(b) What is the actual pressure at the station in Pascals? 1 PSI = 6895 Pa

Act II: Pressure Gradients and Differences

FS.L1.2-04:

Problem Statement: Below shows a chamber with a piston, which is free to move and has a cross-sectional area **A**, in the center that separates the container into two sides.

(a) Which of the following actions will move the piston to the right?



(1) Increase the pressure on the left.
(2) Increase the pressure on the right.
(3) Decrease the pressure on the left.
(4) Decrease the pressure on the right.

(b) Which of the following equations describes the force acting on the piston?

(1) **A·P**
(2) **A/P**
(3) **A·ΔP**
(4) **A/ΔP**

FS.L1.2-05:

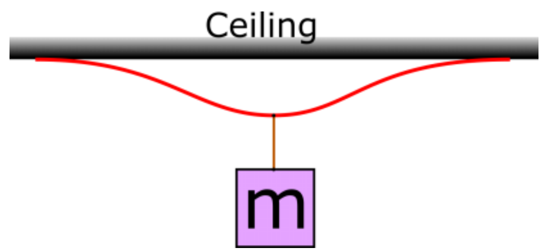
Problem Statement: A 10.0-cm-diameter suction cup is pushed against a smooth ceiling at a location near sea level. The mass of the suction cup is negligible compared to the mass hanging from it. Recall that $\mathbf{P_{atm}}$ = 101.3 kPa

(a) What is the pressure right outside of the suction cup?

(1) $\mathbf{P_{atm}}$
(2) Less than $\mathbf{P_{atm}}$
(3) Greater than $\mathbf{P_{atm}}$

(b) What is the pressure inside the suction cup?

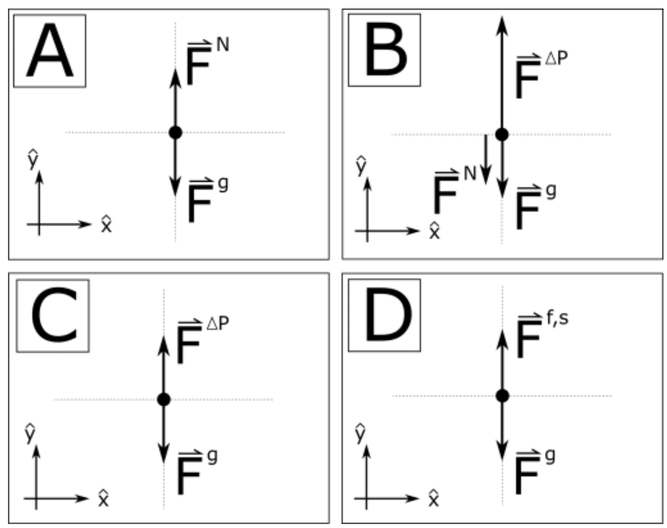
(1) $\mathbf{P_{atm}}$
(2) Less than $\mathbf{P_{atm}}$
(3) Greater than $\mathbf{P_{atm}}$



(c) What force is holding the mass-cup system up?

(1) Normal force
(2) Friction force
(3) Force from pressure difference
(4) Gravity

(d) Which of the FBD's is correct for the cup mass system?



(e) Which of the following expressions could be used to determine the force from the pressure difference?

(1) **A·P**
(2) **A/P**
(3) **A·ΔP**
(4) **A/ΔP**

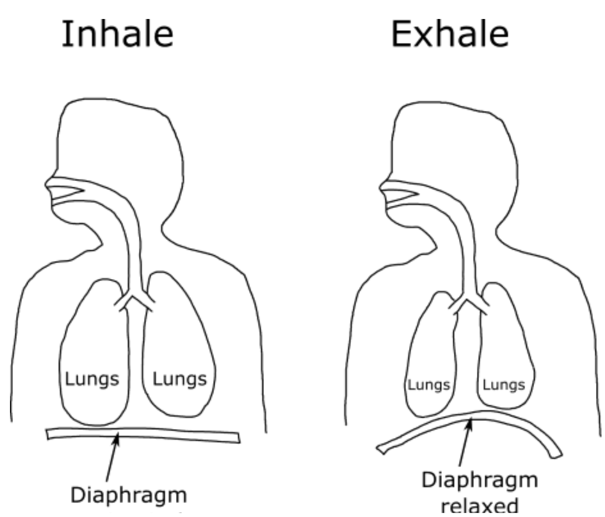
(f) At the critical point where the cup is holding the largest mass possible, which of the following forces go to zero?

(1) Normal force
(2) Friction force
(3) Force from pressure difference
(4) Gravity

(g) A 10.0-cm-diameter suction cup is pushed against a smooth ceiling at a location near sea level. The mass of the suction cup is negligible compared to the mass hanging from it. Recall that $\mathbf{P_{atm}}$ = 101.3 kPa **Calculate the maximum mass the suction cup can hold before it peels off the ceiling.**

FS.L1.2-06:

Problem Statement: Three students are discussing how human lungs given the simplified models of inhaling and exhaling below. Which student do you agree with the most?



(1) It looks like the diaphragm contracts when we inhale, thus creating a larger volume in the chest cavity where the lungs are. If we model air as an ideal gas at roughly a constant temperature, then as the volume of the lungs increases the pressure also increases which sucks air into the lungs.

(2) I agree that as the diaphragm contracts the volume of the chest cavity and thus lungs increases. But if we model the air as an ideal gas, then this increase in volume would cause a decrease in pressure. Since the pressure outside out mouth is roughly atmospheric, and the pressure in our lungs is now decreases, air gets pushed into our lungs because of the pressure difference.

(3) I think we need to look at both the inhale and exhale pictures. During the inhale, the diaphragm pulls air down with it as it contracts, then on the exhale the diaphragm pushes the air up and back out of the

mouth.

contracted

FS.L1.2-07:

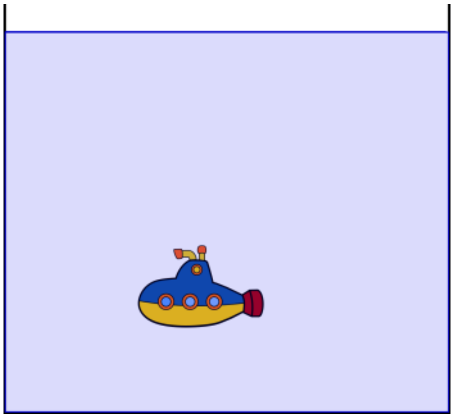
Problem Statement: Is it easier or harder to suck through a straw on the moon?

(1) Easier
(2) Harder
(3) Same effort
(4) Impossible

Act III: Hydrostatic Pressure at a Depth

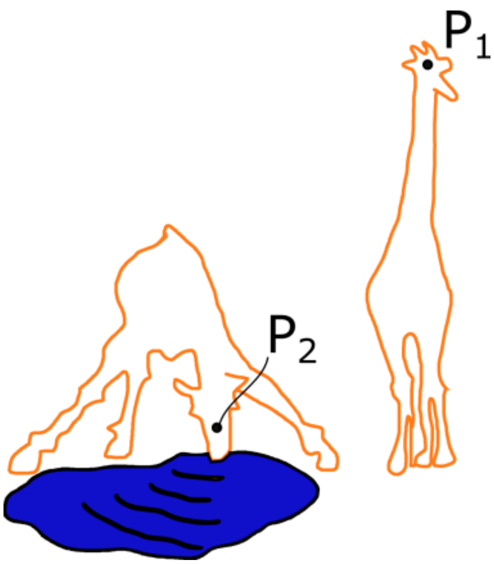
FS.L1.2-08:

Problem Statement: When a submarine dives down to a depth of 120 m, to how large a total pressure is the exterior of the submarine subjected to? The density of seawater is 1030 kg/m^3.



FS.L1.2-09:

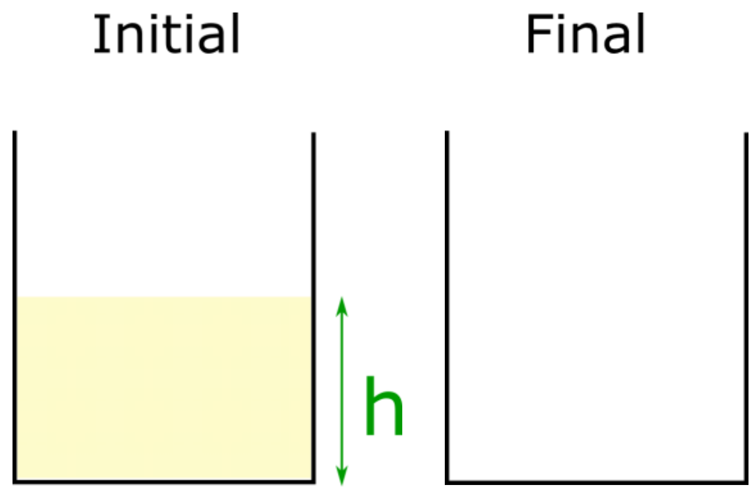
Problem Statement: Calculate the difference in pressure that the blood vessels in a giraffe's head have to accommodate as the head is lowered from a full upright position to the ground level for a drink. The height of an average giraffe is about 6 m. The density of blood is about 1050 kg/m3.



FS.L1.2-10:

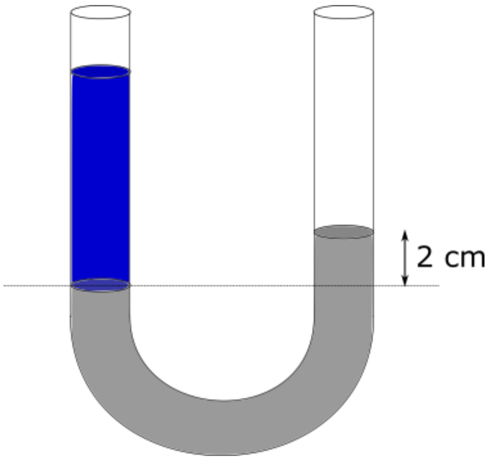
Problem Statement: A beaker is filled with a fluid **A** to a depth of **h** and the pressure at the bottom of the fluid is found to be equal to $\mathbf{P_1} = \boldsymbol{\rho_A}\, \mathbf{g}\, \mathbf{h}$. Fluid **B**, which is 3 times as dense as fluid **A**, is also added. If only half as much as **A** of fluid **B** is added, what is the new pressure at the bottom of the beaker?

(1) 1/3 $\mathbf{P_1}$
(2) 1/2 $\mathbf{P_1}$
(3) 2/3 $\mathbf{P_1}$
(4) $\mathbf{P_1}$
(5) 3/2 $\mathbf{P_1}$
(6) 5/2 $\mathbf{P_1}$
(7) 2 $\mathbf{P_1}$
(8) 3 $\mathbf{P_1}$



FS.L1.2-11:

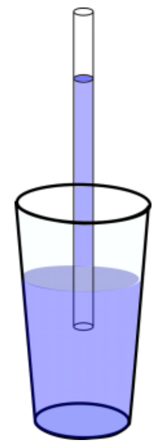
Problem Statement: A U-Tube which is open to the atmosphere on both ends is initially filled with mercury, then an unknown amount of water is poured into the left hand side of the tube. The water and mercury don't mix and the equilibrium state is shown in the image below. The mercury is pushed up 2 cm on the right hand side. To what height above the given reference line does the water extend up to? The density of mercury is about 13600 kg/m3.



FS.L1.2-12:

Problem Statement: Steve is selling a vibranium straw that is 5.0 m long for a price of $20. Steve's good pal is also selling a straw that is made out of uru metal for $20 but is 20 m long. You wish to buy a straw to be used for drinking from a cup of water in the vertical direction on the surface of the Earth. Neither of these straws can be cut into smaller pieces.

(a) What is the tallest column of water you can get up a straw near the surface of the earth?



(b) Which straw would you buy and why?

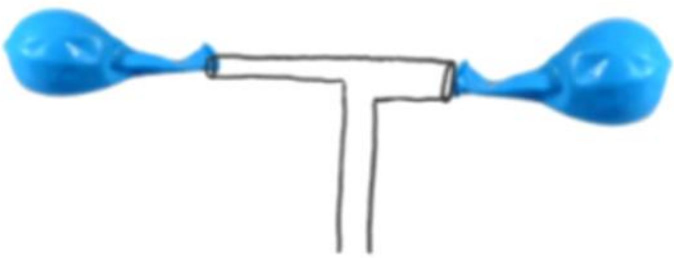
Act IV: Pascal's Principle

FS.L1.2-13:

Problem Statement: Two identical uninflated balloons are connected to a T-shaped tube as shown below.

(a) When air is blown into the open end of the tube,

(1) the balloon on the left inflates more at equilibrium.
(2) the balloon on the right inflates more at equilibrium.
(3) both balloons inflate equally at equilibrium.

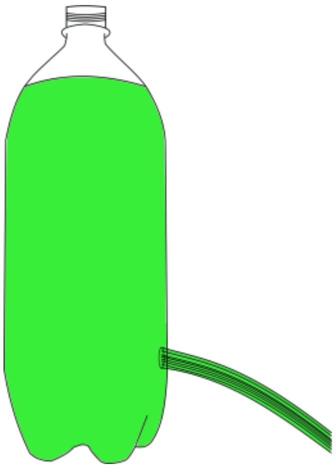


(b) What will be the difference between the two balloons?

FS.L1.2-14:

Problem Statement: When a hole is made in the side of a container holding water, water flows out and follows a parabolic trajectory as shown in the image below. If the container is dropped in free fall, the water flow

(1) diminishes.
(2) stops altogether.
(3) goes out in a straight line.
(4) curves upwards.



Conceptual questions for discussion

1. Coming soon.

Hints

FS.L1.2-01: No hints.

FS.L1.2-02: No hints.

FS.L1.2-03: No hints.

FS.L1.2-04: No hints.

FS.L1.2-05: No hints.

FS.L1.2-06: No hints.

FS.L1.2-07: No hints.

FS.L1.2-08: No hints.

FS.L1.2-09: No hints.

FS.L1.2-10: No hints.

FS.L1.2-11: No hints.

FS.L1.2-12: No hints.

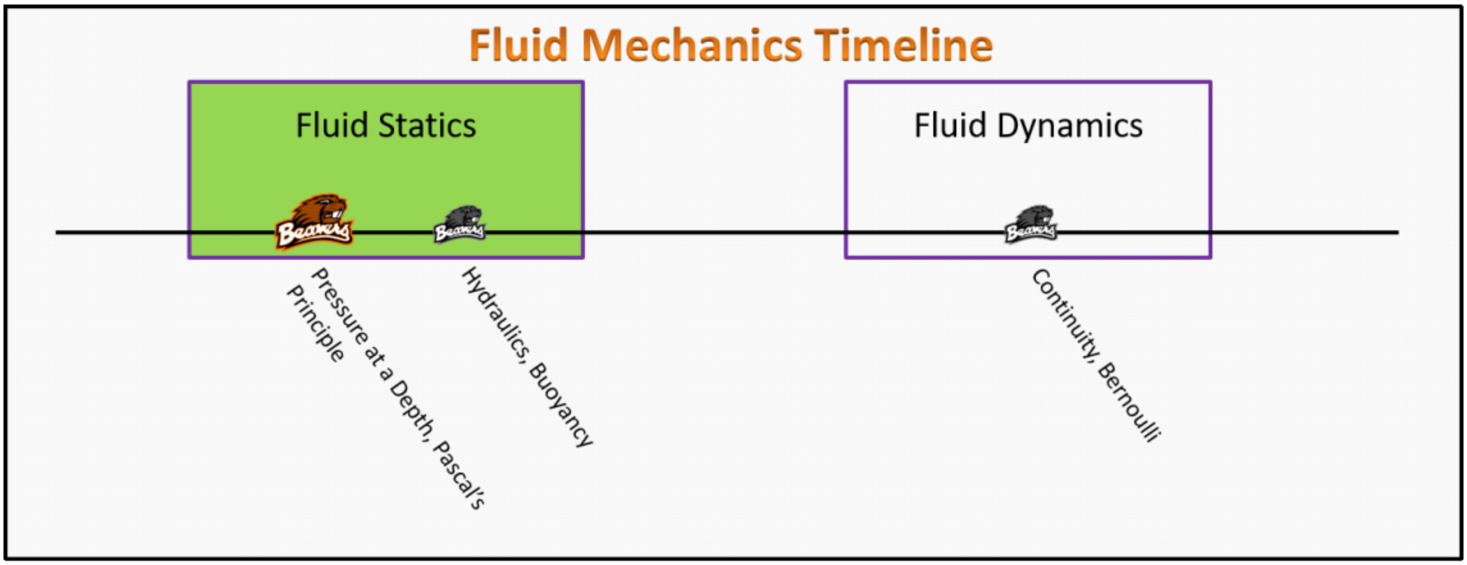
FS.L1.2-13: No hints.

FS.L1.2-14: No hints.

Fluid Statics

Practice Stage (FS.L1.3)

Lecture 1
Pressure at a Depth, Pascal's Principle



FS.L1.3-01

Description: Find pressure exerted by a fluid mass

Learning Objectives: [x]

Problem Statement: What pressure is exerted on the bottom of a 0.500-m-wide by 0.900-m-long gas tank that can hold 50.0 kg of gasoline by the weight of the gasoline in it when it is full?

(1) 1.11×10^{2} N/m^2
(2) 2.20×10^{2} N/m^2
(3) 9.18×10^{-4} N/m^2
(4) 1.09×10^{3} N/m^2

FS.L1.3-02

Description: Finding pressure in bicycle tires that will exert the proper force

Learning Objectives: [x]

Problem Statement: Assuming bicycle tires are perfectly flexible and support the weight of bicycle and rider by pressure alone, calculate the total area of the tires in contact with the ground. The bicycle plus rider has a mass of 80.0 kg, and the gauge pressure in the tires is 3.50×10^5 Pa.

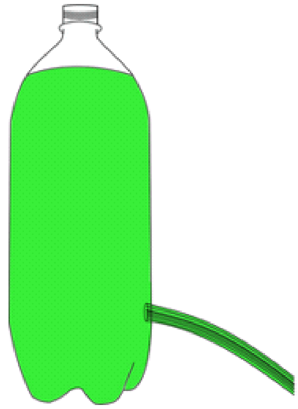
(1) 2.29cm^2
(2) 22.4cm^2
(3) 0.002cm^2
(4) 446cm^2

FS.L1.3-03

Description: Conceptual question about fluid flow from a hole in a container

Learning Objectives: [x]

Problem Statement: When a hole is made in the side of a container holding water, the water flows out and follows a parabolic trajectory as shown in the image. As the water level decreases in the container, what happens to the water flowing out?



(1) The water hits the ground farther from the container
(2) The water hits the ground closer to the container
(3) The water hits the ground at the same position

FS.L1.3-04

Description: Pressure at a depth calculation

Learning Objectives: [x]

Problem Statement: In July 2015, Oregon State University, the National Oceanic and Atmospheric Administration, and the Coast Guard cooperated to send a hydrophone into Challenger Deep, the deepest part of the Mariana Trench. The titanium shelled recording device withstood the pressure 10,994 meters (nearly 7 miles!) under the ocean's surface. The hydrophone recorded 23 days of audio from the deepest part of the ocean floor. If the spherical hydrophone has a radius of 10 cm, what is the total force exerted on the titanium shell by the ocean water?

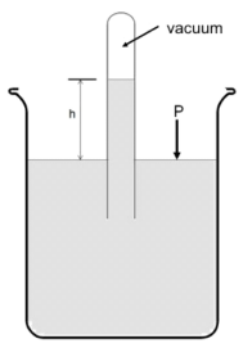
(1) 1,380,000 N
(2) 13,500,000 N
(3) 135,000,000,000 N
(4) 45,100000 N

FS.L1.3-05

Description: Barometer question involving atmospheric pressure and an evacuated cylinder

Learning Objectives: [x]

Problem Statement: This figure shows a barometer, which is filled with mercury. The height of the column of mercury is h=1200mm. In units of atmospheres, what is the pressure P?



(1) 1.6 atm
(2) 0.16 atm
(3) 1.0 atm
(4) 92000 atm

FS.L1.3-06

Description: Conceptual and workout questions about breathing through a straw underwater

Learning Objectives: [x]

Problem Statement: Heroes in movies hide beneath water and breathe through a hollow reed (villains never catch on to this trick).

(a) How does this affect our hero's ability to breathe when compared to breathing normally on dry land?

(1) It is easier for our hero to breathe while underwater
(2) It is more difficult for our hero to breathe while underwater
(3) Breathing is not easier or more difficult for our hero

(b) If our hero can create a gauge pressure of -5500 Pa in their lungs, how deep underwater is our hero able to breathe?

(1) As deep as our hero chooses. It is easier to breathe the deeper they go.
(2) 10 m beneath the surface
(3) 9.78 m beneath the surface
(4) 5.5 m beneath the surface
(5) 56 cm beneath the surface