The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Science A Physics

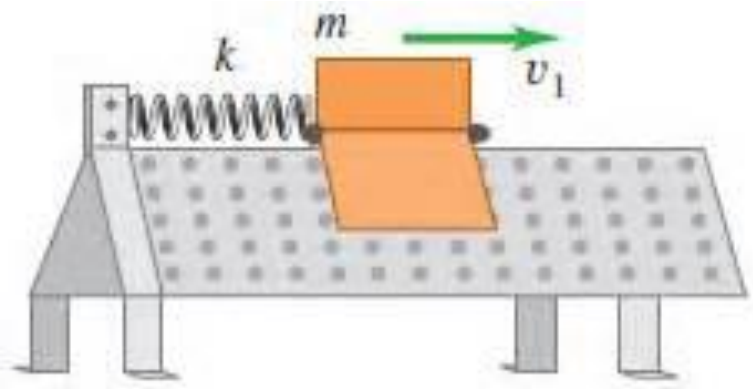
Lectures 7-12:

Additional Problems: Simple Harmonic Motion, Fluids and Light.

Frequency and Period of a Loudspeaker Cone

Q.1 What is the oscillator period of a loudspeaker cone that vibrates back and forth 5000 times per second?

A System in Simple Harmonic Motion



Q.2 An air-track glider is attached to a spring, pulled 20.0 cm to the right, and released at t = 0 s. It makes 15 oscillations in 10.0 s.

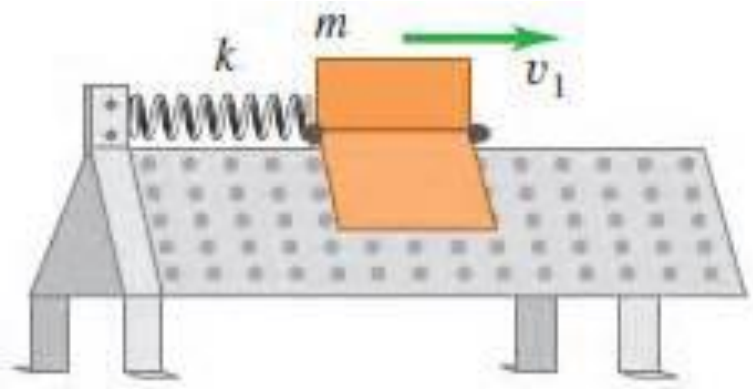
a. What is the period of oscillation?

b. What is the object's maximum speed?

c. What are the position and velocity at t = 0.800 s?

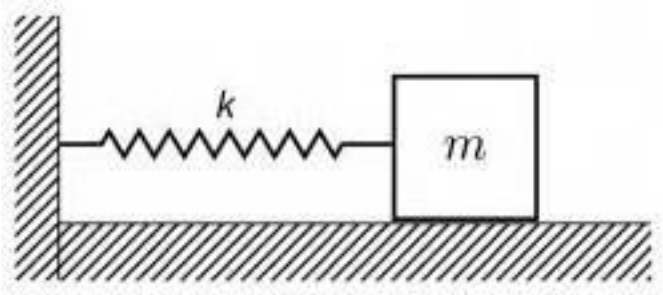
MODEL: An object oscillating on a spring is in SHM.

Using the Initial Conditions



Q.3 An object on a spring oscillates with a period of 0.80 s and an amplitude of 10 cm. At t = 0 s, it is 5.0 cm to the left of equilibrium and moving to the left. What are its position and direction of motion at t = 2.0 s?

Using Conservation of Energy

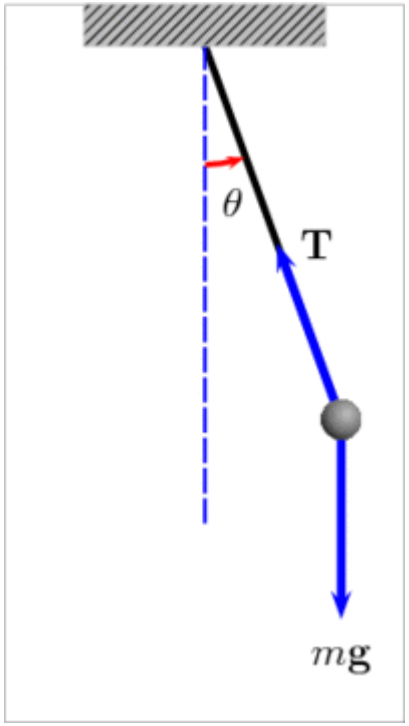


Q.4 A 500 g block on a spring is pulled a distance of 20 cm and released. The subsequent oscillations are measured to have a period of 0.80 s.

a. At what position or positions is the block's speed 1.0 m/s?

b. What is the spring constant?

The Maximum Angle of a Pendulum



Q.5 A 300 g mass on a 30-cm-long string oscillates as a pendulum. It has a speed of 0.25 m/s as it passes through the lowest point. What maximum angle does the pendulum reach?

A Suction Cup

Q.6 A 10.0-cm-diameter suction cup is pushed against a smooth ceiling. What is the maximum mass of an object that can be suspended from the suction cup without pulling it off the ceiling? The mass of the suction cup is negligible.

TACTICS BOX 15.1 Hydrostatics

1. **Draw a picture.** Show open surfaces, pistons, boundaries, and other features that affect pressure. Include height and area measurements and fluid densities. Identify the points at which you need to find the pressure.
2. **Determine the pressure at surfaces.**
   - **Surface open to the air:** $p_0 = p_{\text{atmos}}$, usually 1 atm.
   - **Surface covered by a gas:** $p_0 = p_{\text{gas}}$.
   - **Closed surface:** $p = F/A$, where F is the force the surface, such as a piston, exerts on the fluid.
3. **Use horizontal lines.** Pressure in a connected fluid is the same at any point along a horizontal line.
4. **Allow for gauge pressure.** Pressure gauges read $p_g = p - 1$ atm.
5. **Use the hydrostatic pressure equation.** $p = p_0 + \rho g d$.

Exercises 4–13

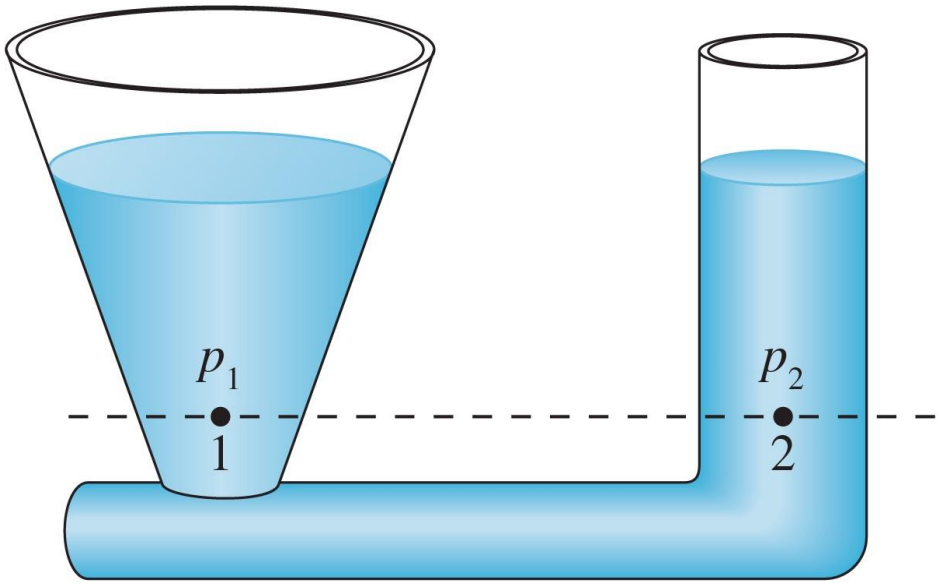
Pressure on a Submarine

Q.7 A submarine cruises at a depth of 300 m. What is the pressure at this depth? Give the answer in both Pascals and atmospheres.

Liquids in Hydrostatic Equilibrium

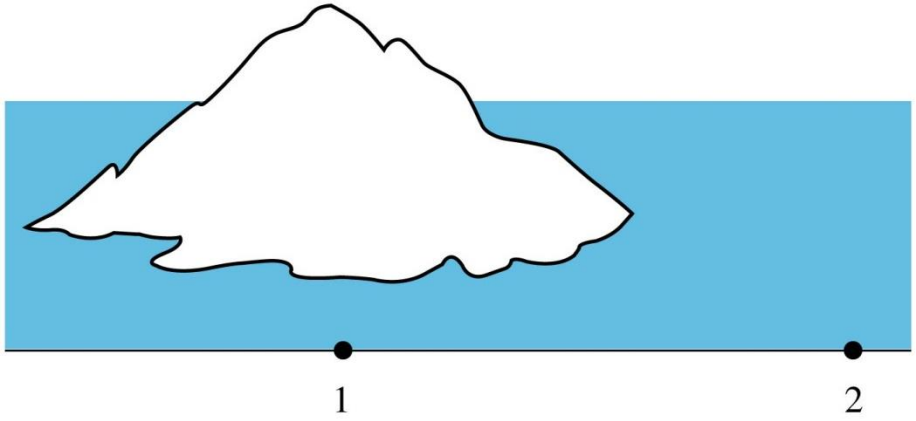
Q.8 What can you say about the pressures at points 1 and 2?

a) $p_1 > p_2$.
b) $p_1 = p_2$.
c) $p_1 < p_2$.



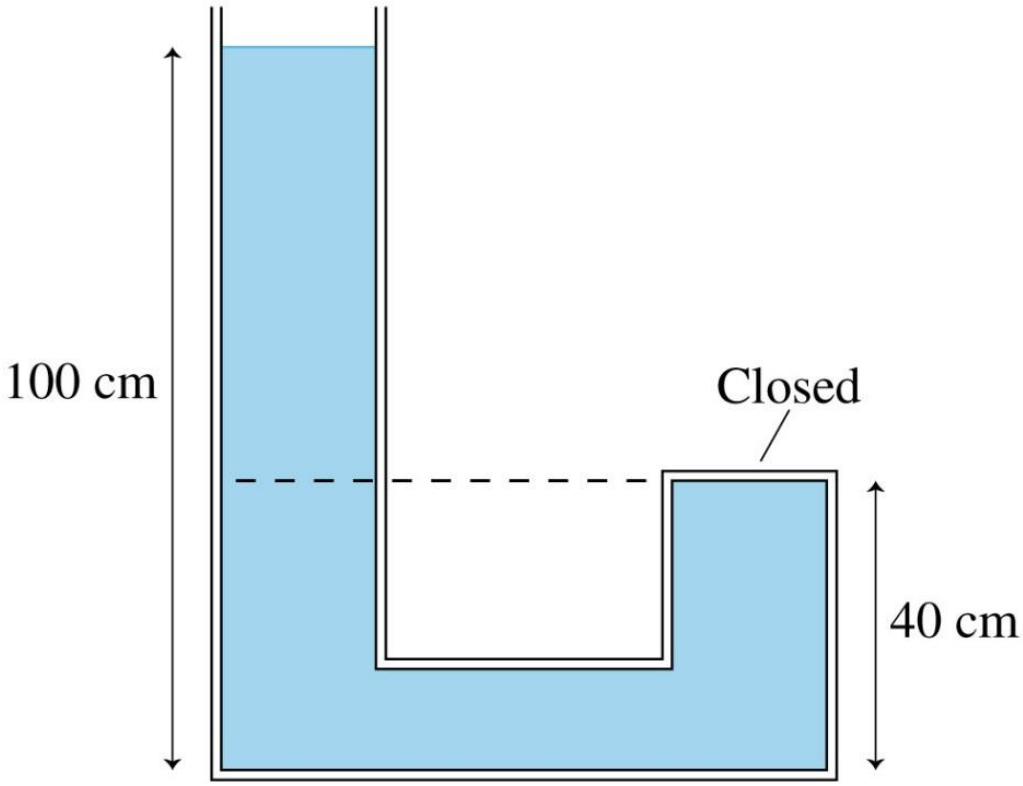
Liquids in Hydrostatic Equilibrium

Q.9 An iceberg floats in a shallow sea. What can you say about the pressures at points 1 and 2?



a) $p_1 > p_2$.
b) $p_1 = p_2$.
c) $p_1 < p_2$.

Pressure in a Closed Tube

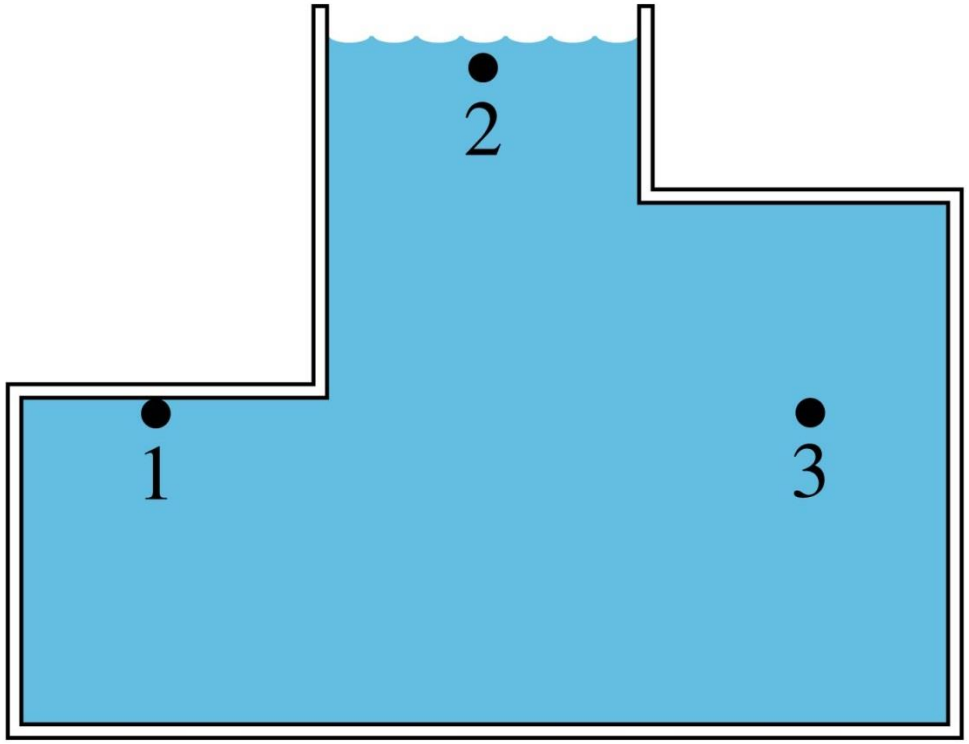


Q.10 Water fills the tube shown in the above figure. What is the pressure at the top of the closed tube?

Pressure in a Closed Tube

Q.11 What can you say about the pressures at points 1, 2, and 3?

a) $p_1 = p_2 = p_3$.
b) $p_1 = p_2 > p_3$.
c) $p_3 > p_1 = p_2$.
d) $p_3 > p_1 > p_2$.
e) $p_1 = p_3 > p_2$.



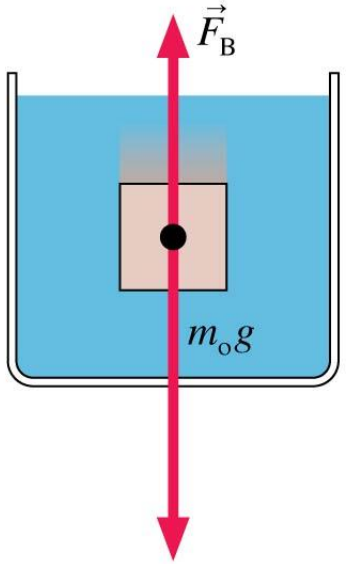
Lifting a Car

Q.12 The hydraulic lift at a car repair shop is filled with oil. The car rests on a 25-cm-diameter piston. To lift the car, compressed air is used to push down on a 6.0-cm-diameter piston. What does the pressure gauge read when a 1300 kg car is 2.0 m above the compressed air piston?

Will an Object Float or Sink?

Finding whether an object floats or sinks

❶ Object sinks



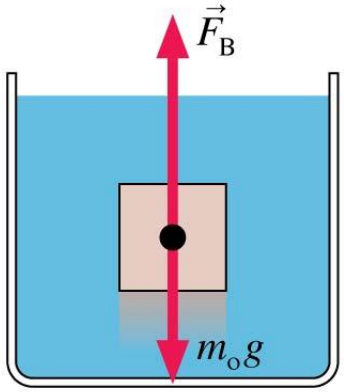
An object sinks if it weighs more than the fluid it displaces—that is, if its average density is greater than the density of the fluid:

$$\rho_{avg} > \rho_f$$

Will an Object Float or Sink?

Finding whether an object floats or sinks

❷ Object floats



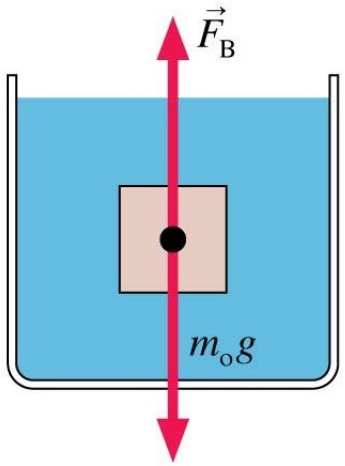
An object floats on the surface if it weighs less than the fluid it displaces—that is, if its average density is less than the density of the fluid:

$$\rho_{avg} < \rho_f$$

Will an Object Float or Sink?

Finding whether an object floats or sinks

❸ Neutral buoyancy



An object hangs motionless if it weighs exactly the same as the fluid it displaces—that is, if its average density equals the density of the fluid:

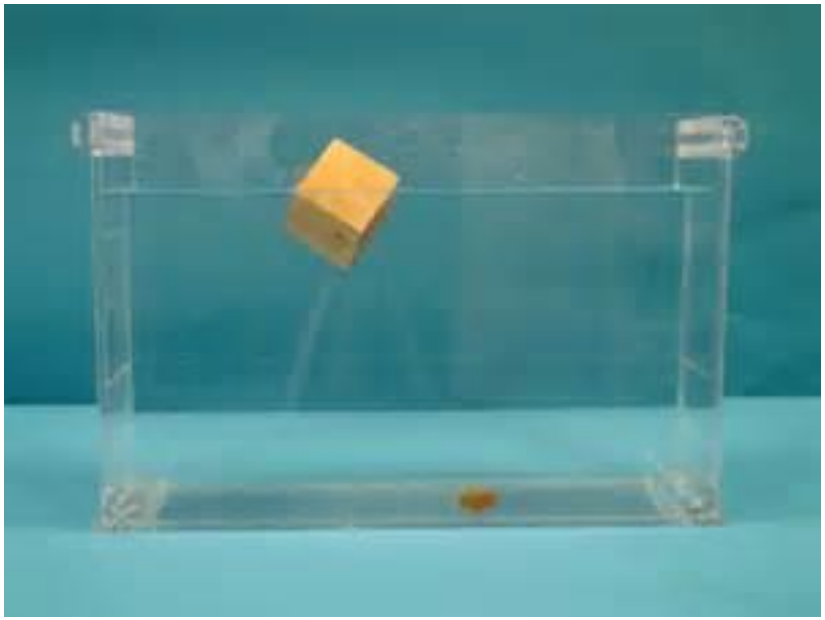
$$\rho_{avg} = \rho_f$$

Buoyancy

Q.13 A heavy lead block and a light aluminum block of equal sizes are both submerged in water. Upon which is the buoyant force greater?

a) On the lead block.
b) On the aluminum block.
c) They both experience the same buoyant force.

Holding a Block of Wood Underwater



Q.14 A 10 cm × 10 cm × 10 cm block of wood with density 700 kg/m^3 is held underwater by a string tied to the bottom of the container. What is the tension in the string?

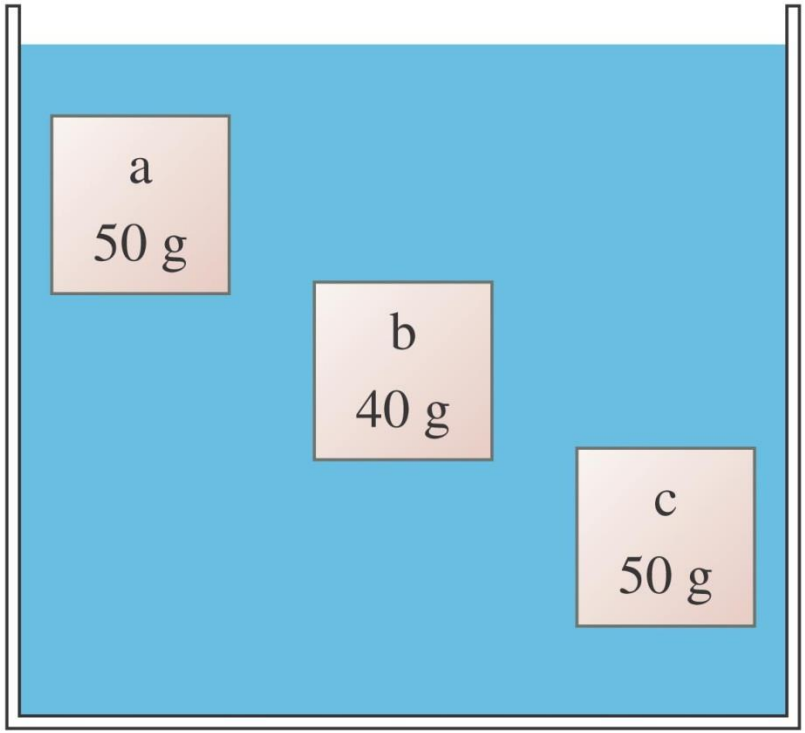
Buoyancy

Q.15 Two blocks are of identical size. One is made of lead and sits on the bottom of a pond; the other is of wood and floats on top. Upon which is the buoyant force greater?

a) On the lead block.
b) On the wood block.
c) They both experience the same buoyant force.

Buoyancy

Q.16 Blocks a, b, and c are all the same size. Which experiences the largest buoyant force?



a) Block a.
b) Block b.
c) Block c.
d) All have the same buoyant force.
e) Blocks a and c have the same buoyant force, but the buoyant force on block b is different.

Bernoulli's Equation

The energy equation for fluid in a flow tube is:

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

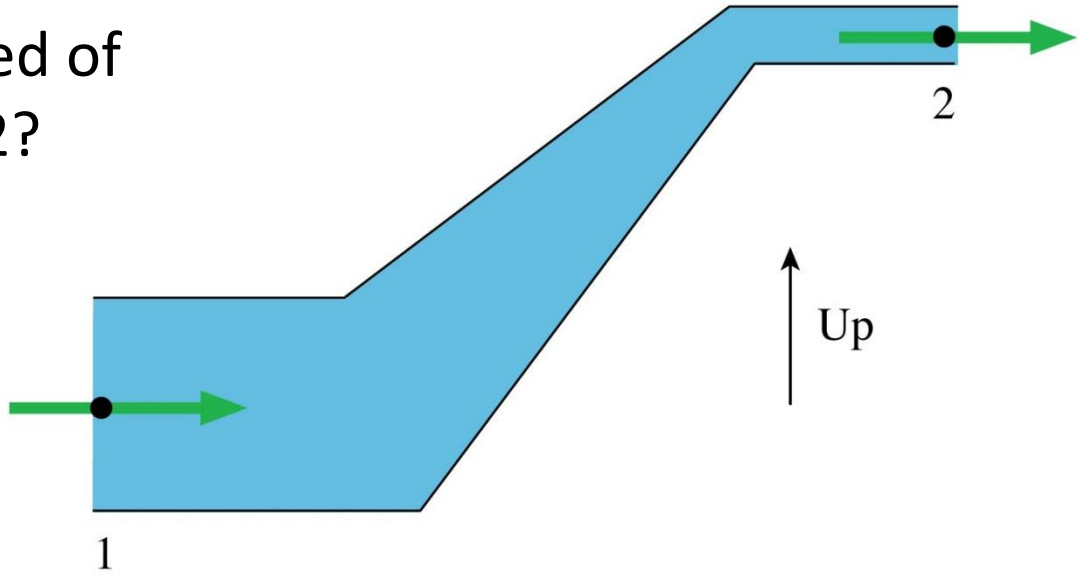
An alternative form of **Bernoulli's equation** is:

$$p + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$$

Fluid Dynamics

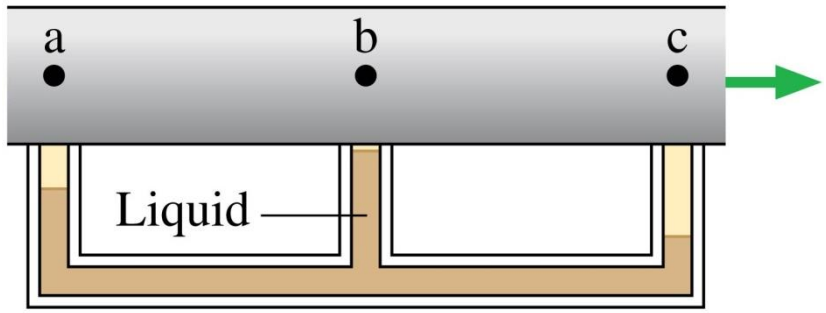
Q.17 Water flows from left to right through this pipe. What can you say about the speed of the water at points 1 and 2?

a) $v_1 > v_2$.
b) $v_1 = v_2$.
c) $v_1 < v_2$.



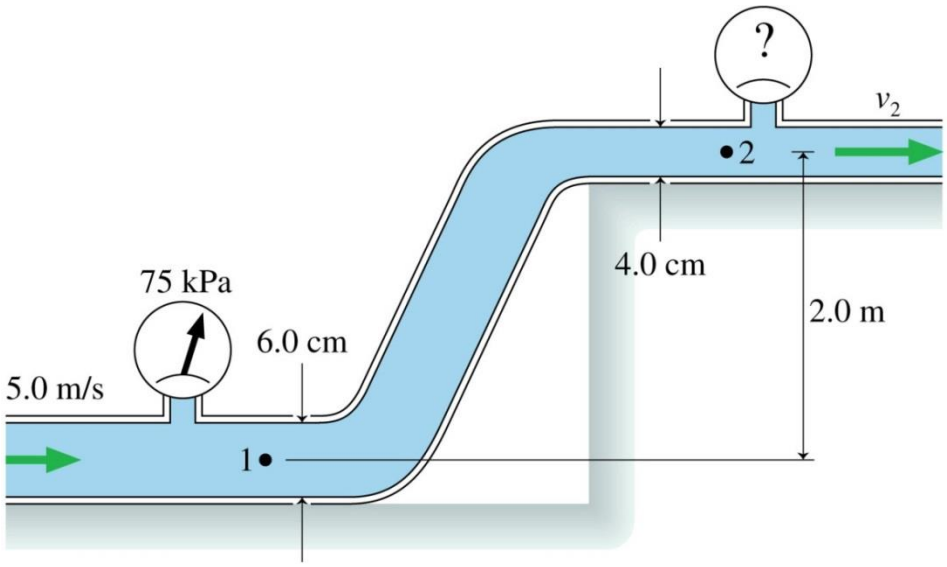
Bernoulli's Equation

Q.18 Gas flows from left to right through this pipe, whose interior is hidden. At which point does the pipe have the smallest inner diameter?



a) Point a.
b) Point b.
c) Point c.
d) The diameter doesn't change.
e) Not enough information to tell.

An Irrigation System



Q.19 Water flows through the pipes shown in the figure. The water's speed through the lower pipe is 5.0 m/s, and a pressure gauge reads 75 kPa. What is the reading of the pressure gauge on the upper pipe?

Light Reflecting from a Mirror

Q.20 A dressing mirror on a closet door is 1.5 m tall. The bottom is 0.50 m above the floor. A bare lightbulb hangs 1.00 m from the closet door, 2.50 m above the floor. How long is the streak of reflected light across the floor?

The Plane Mirror

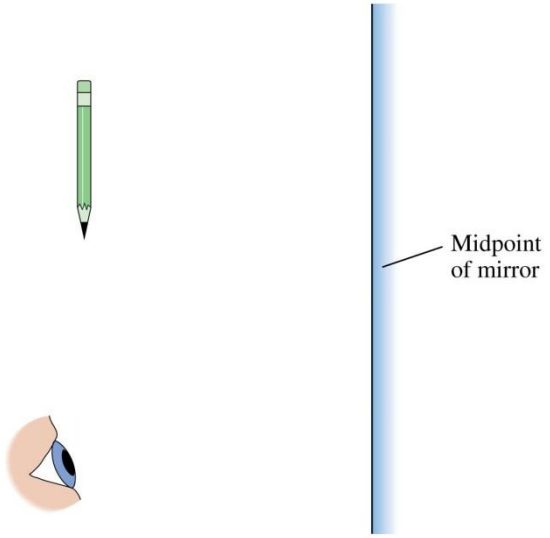
Q.21 You are looking at the image of a pencil in a mirror. What do you see in the mirror if the top half of the mirror is covered with a piece of dark paper?

a) The full image of the pencil.

b) The top half only of the pencil.

c) The bottom half only of the pencil.

d) No pencil, only the paper.



How High is the Mirror?

Q.22 If your height is h, what is the shortest mirror on the wall in which you can see your full image? Where must the top of the mirror be hung?

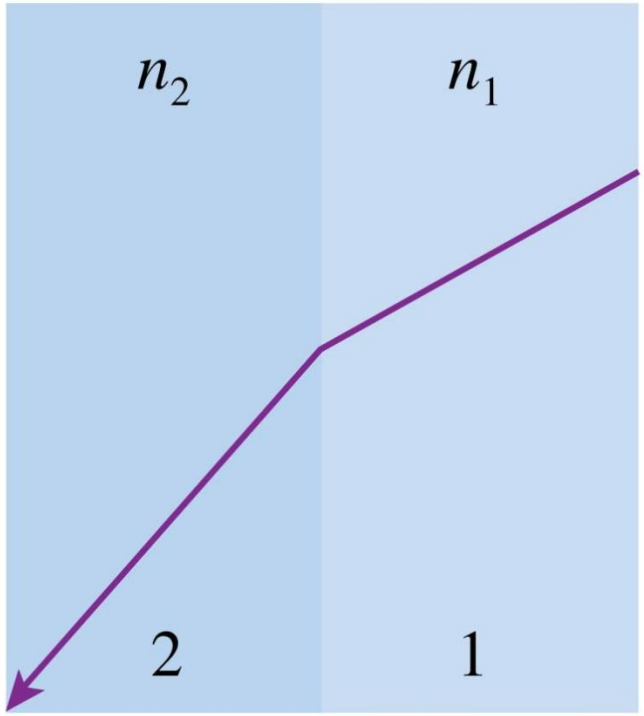
TACTICS BOX 23.1 Analyzing refraction

1. **Draw a ray diagram.** Represent the light beam with one ray.
2. **Draw a line normal to the boundary.** Do this at each point where the ray intersects a boundary.
3. **Show the ray bending in the correct direction.** The angle is larger on the side with the smaller index of refraction. This is the qualitative application of Snell's law.
4. **Label angles of incidence and refraction.** Measure all angles from the normal.
5. **Use Snell's law.** Calculate the unknown angle or unknown index of refraction.

Exercises 11–15

Refraction

Q.23 A laser beam passing from medium 1 to medium 2 is refracted as shown. Which is true?

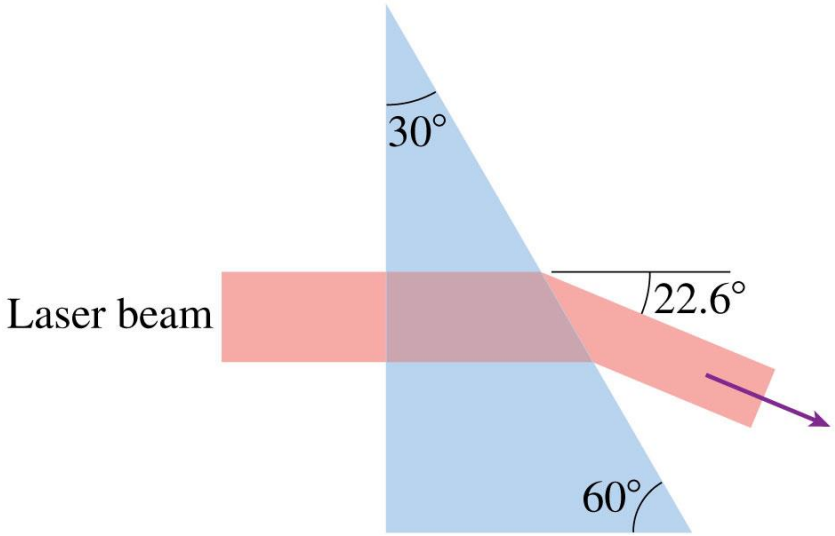


a) $n_1 < n_2$.

b) $n_1 > n_2$.

c) There's not enough information to compare n_1 and n_2.

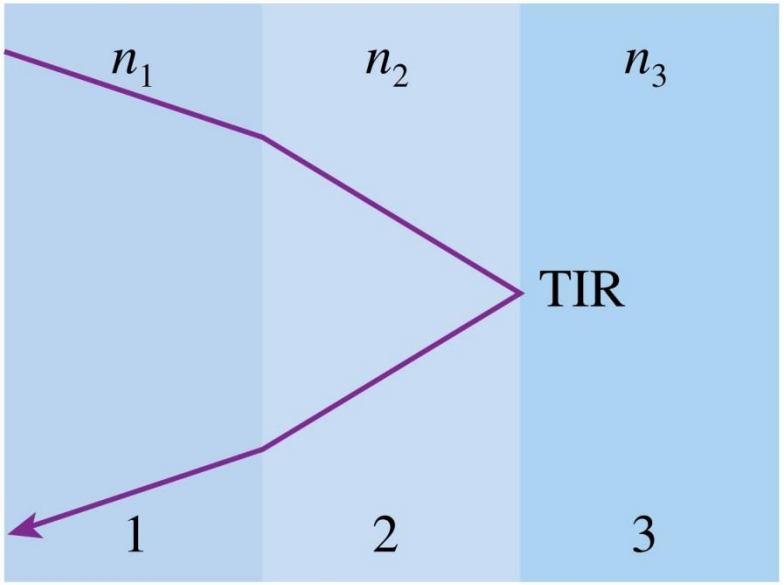
Measuring the Index of Refraction



Q.24 The figure above shows a laser beam deflected by a prism. What is the prism's index of refraction?

Total Internal Reflection

Q.25 A laser beam undergoes two refractions plus total internal reflection at the interface between medium 2 and medium 3. Which is true?



a) $n_1 < n_3$.

b) $n_1 > n_3$.

c) There's not enough information to compare n_1 and n_3.