AP®

Introduction: Fluids & Pressure

Unit: Fluids & Pressure

Topics covered in this chapter:

In this chapter you will learn about pressure and behaviors of fluids.

- *Pressure* explains pressure as a force spread over an area. Pressure is the property that is central to the topic of fluid mechanics.
- *Hydraulic Pressure and Hydrostatic Pressure* describe how pressure acts in two common situations.
- *Buoyancy* descries the upward pressure exerted by a fluid that causes objects to float.
- *Fluid Motion & Bernoulli's Law* describes the relationship between pressure and fluid motion.

This chapter focuses on real-world applications of fluids and pressure, including more demonstrations than most other topics. One of the challenges in this chapter is relating the equations to the behaviors seen in the demonstrations.

This unit is *Unit 8: Fluids* from the 2024 AP® Physics 1 Course and Exam Description.

Standards addressed in this chapter:

NGSS Standards/MA Curriculum Frameworks (2016):

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.

HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations.

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AP® Physics 1 Learning Objectives/Essential Knowledge (2024):

8.1.A: Describe the properties of a fluid.

8.1.A.1: Distinguishing properties of solids, liquids, and gases stem from the varying interactions between atoms and molecules.

8.1.A.2: A fluid is a substance that has no fixed shape.

8.1.A.3: Fluids can be characterized by their density. Density is defined as a ratio of mass to volume.

8.1.A.4: An ideal fluid is incompressible and has no viscosity.

8.2.A: Describe the pressure exerted on a surface by a given force.

8.2.A.1: Pressure is defined as the magnitude of the perpendicular force component exerted per unit area over a given surface area, as described by the equation $P = \frac{F_{\perp}}{A}$.

8.2.A.2: Pressure is a scalar quantity.

8.2.A.3: The volume and density of a given amount of an incompressible fluid is constant regardless of the pressure exerted on that fluid.

8.2.B: Describe the pressure exerted by a fluid.

8.2.B.1: The pressure exerted by a fluid is the result of the entirety of the interactions between the fluid's constituent particles and the surface with which those particles interact.

8.2.B.2: The absolute pressure of a fluid at a given point is equal to the sum of a reference pressure P_o, such as the atmospheric pressure P_{atm}, and the gauge pressure P_{gauge}.

8.2.B.3: The gauge pressure of a vertical column of fluid is described by the equation $P_{gauge} = \rho gh$.

8.3.A: Describe the conditions under which a fluid's velocity changes.

8.3.A.1: Newton's laws can be used to describe the motion of particles within a fluid.

8.3.A.2: The macroscopic behavior of a fluid is a result of the internal interactions between the fluid's constituent particles and external forces exerted on the fluid.

8.3.B: Describe the buoyant force exerted on an object interacting with a fluid.

8.3.B.1: The buoyant force is a net upward force exerted on an object by a fluid.

8.3.B.2: The buoyant force exerted on an object by a fluid is a result of the collective forces exerted on the object by the particles making up the fluid.

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8.3.B.3: The magnitude of the buoyant force exerted on an object by a fluid is equivalent to the weight of the fluid displaced by the object.

8.4.A: Describe the flow of an incompressible fluid through a cross-sectional area by using mass conservation.

8.4.A.1: A difference in pressure between two locations causes a fluid to flow.

8.4.A.1.i: The rate at which matter enters a fluid-filled tube open at both ends must equal the rate at which matter exits the tube.

8.4.A.1.ii: The rate at which matter flows into a location is proportional to the crosssectional area of the flow and the speed at which the fluid flows.

8.4.A.2: The continuity equation for fluid flow describes conservation of mass flow rate in incompressible fluids.

8.4.B: Describe the flow of a fluid as a result of a difference in energy between two locations within the fluid-Earth system.

8.4.B.1: A difference in gravitational potential energies between two locations in a fluid will result in a difference in kinetic energy and pressure between those two locations that is described by conservation laws.

8.4.B.2: Bernoulli's equation describes the conservation of mechanical energy in fluid flow.

8.4.B.3: Torricelli's theorem relates the speed of a fluid exiting an opening to the difference in height between the opening and the top surface of the fluid and can be derived from conservation of energy principles.

Skills learned & applied in this chapter:

- Before & after problems.

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