

PHYSICS

3. YEAR

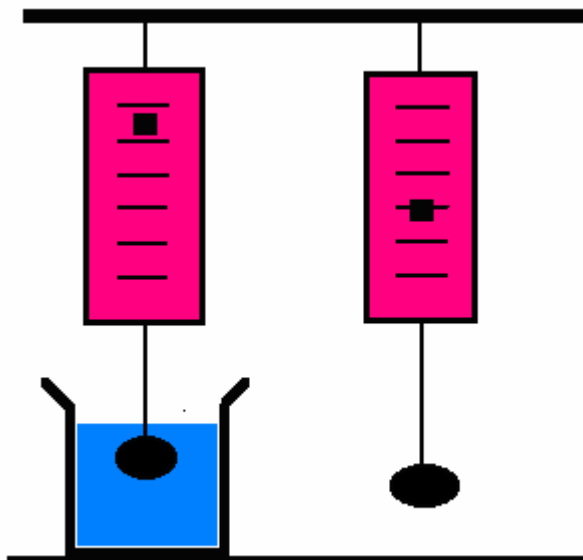


CAPILLARITY ACTION

The diagram at right shows how water acts when placed in a glass or plastic cylinder. It happens with some other substances as well. The adhesion of the water for the glass allows the water to move up the wall of the cylinder just a little above the level of the water in the center of the cylinder. Cohesion of water molecules cause the gradual curve observed.



ARCHIMEDES'S PRINCIPLE



A body submerged in a fluid experiences a buoyant force equal to the weight of the displaced fluid. Let W_A be the weight of the aluminum in air, W_W be the weight of the aluminum when submerged, and w be the weight of an equal volume of water. The ratio of the density (D) of the aluminum to the density (d) of the water is equal to the weight (W) of the aluminum divided by the weight (w) of the water displaced. One measures w by measuring $W_A - W_W$ and INVOKING the principle, or by measuring the displaced volume of water, using the known density of water, and PROVING the principle. The density of the aluminum is then given by:

$$D = d[W_A / (W_A - W_W)]$$

BERNOULLI'S PRINCIPLE

Bernoulli's principle states that flowing **fluids** like air and water press less than still fluids and that **pressure** decreases quadratically with speed; i.e., with speed-squared.

One quarter of a millennium ago, **Daniel Bernoulli** pioneered use of kinetic theory that molecules moved and bumped things. He also knew that flowing fluids pressed less, but he did not connect these ideas logically. In *Hydrodynamic*, Daniel's logic that flow reduced pressure was obscure, and his formula was awkward. Daniel's father Johann, amid controversy, improved his son's insight and presentation in *Hydraulica*. This research was centered in St. Petersburg where Leonard Euler, a colleague of Daniel and a student of Johann, generalized a rate-of-change dependence of pressure and **density** on speed of flow. Bernoulli's Principle for liquids was then formulated in modern form for the first time.

In this same group of scientists was D'Alembert, who found paradoxically that fluids stopped ahead of obstacles, so frictionless flow did not push.

Progress then seems to have halted for about a century and a half until Ludwig Prandtl or one of his students solved Euler's equation for smooth streams of air in order to have a mathematical model of flowing air for designing wings. Here, speed lowers pressure more than it lowers density because expanding air cools, and the ratio of density times degrees-kelvin divided by pressure is constant for an ideal-gas.

More turbulent flow, as in atmospheric winds, requires an alternative solution of Euler's equation because mixing keeps air-temperature fixed.

Bernoulli's principle is regarded by many as a paradox because currents and winds upset things, but standing a stick in a stream of water helps to clarify the enigma. You will see calm, smooth, level water ahead of the stick and a cavity of reduced pressure behind it. Calm water pushes the stick, as lower pressure downstream fails to balance the upsetting **force**.

Bernoulli's principle never acts alone; it also comes with molecular entrainment. Molecules in the lower pressure of faster flow aspirate and whisk away molecules from the higher pressure of slower flow. Solid obstacles such as airfoils carry a very thin stagnant layer of air with them. A swift low-pressure airstream takes some molecules from this boundary layer and reduces molecular impacts on that surface of the wing across which the airstream moves faster.

For Bernoulli's principle to dominate a dynamic situation, **friction** must be less dominant. Elastic molecular impacts are frictionless-no heating. Molecules of dry air, even more than those of water, collide elastically; so Bernoulli's principle with its molecular-entrainment agent is in fact, to use a vernacular cliché, the only game in town for windy air.

MOTION OF THE MOON AND PLANETS

In this exercise students analyse data about the motion of the planets to discover Kepler's three laws. They investigate the consequence of the non-constant speed of the earth in its orbit - the variation in the length of the day. The centre of mass of the Earth/Moon system is

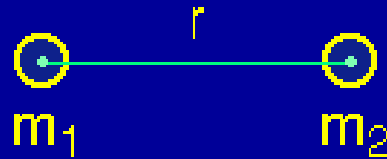
investigated. Students investigate the motion of the two bodies relative to their centre of mass and discover the centripetal force acting towards the centre of mass is the same for each.

Sir Isaac Newton: The Universal Law of Gravitation

Law of Universal Gravitation

Every object in the Universe attracts every other object with a force directed along the line of centers for the two objects that is proportional to the product of their masses and inversely proportional to the square of the separation between the two objects.

$$F_g = G \frac{m_1 m_2}{r^2}$$



F_g is the gravitational force

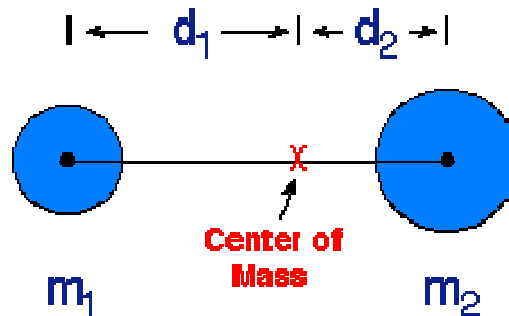
m_1 & m_2 are the masses of the two objects

r is the separation between the objects

G is the universal gravitational constant

CENTER OF MASS

The Center of Mass for a Binary System. If you think about it a moment, it may seem a little strange that in Kepler's Laws the Sun is fixed at a point in space and the planet revolves around it. Why is the Sun privileged? Kepler had rather mystical ideas about the Sun, endowing it with almost god-like qualities that justified its special place. However Newton, largely as a corollary of his 3rd Law, demonstrated that the situation actually was more symmetrical than Kepler imagined and that the Sun does not occupy a privileged position; in the process he modified Kepler's 3rd Law.



Consider the diagram shown to the right. We may define a point called the center of mass between two objects through the equations

$$m_1 d_1 = m_2 d_2$$

$$d_1 + d_2 = R$$

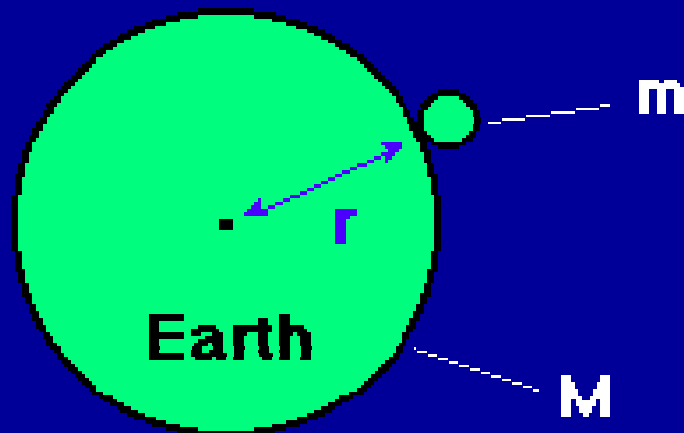
where R is the total separation between the centers of the two objects. The center of mass is familiar to anyone who has ever played on a see-saw. The fulcrum point at which the see-saw will exactly balance two people sitting on either end is the center of mass for the two persons sitting on the see-saw.

WEIGHT AND THE GRAVITATIONAL FORCE

We have seen that in the Universal Law of Gravitation the crucial quantity is mass. In popular language mass and weight are often used to mean the same thing; in reality they are related but quite different things. What we commonly call weight is really just the *gravitational force* exerted on an object of a certain mass. We can illustrate by choosing the Earth as one of the two masses in the previous illustration of the Law of Gravitation:

Thus, the weight of an object of mass m at the surface of the Earth is obtained by multiplying the mass m by the acceleration due to gravity, g , at the surface of the Earth. The acceleration due to gravity is approximately the product of the universal gravitational constant G and the mass of the Earth M , divided by the radius of the Earth, r , squared. (We assume the Earth to be spherical and neglect the radius of the object relative to the radius of the Earth in this discussion.) The measured gravitational acceleration at the Earth's surface is found to be about 980 cm/second/second.

Obr.:



$$\text{Weight} = F_g = G \frac{Mm}{r^2} = mg$$

$= g$

M is the mass of the Earth

m is the mass of the object

r is the radius of the Earth

g is the acceleration due to gravity at the Earth's surface