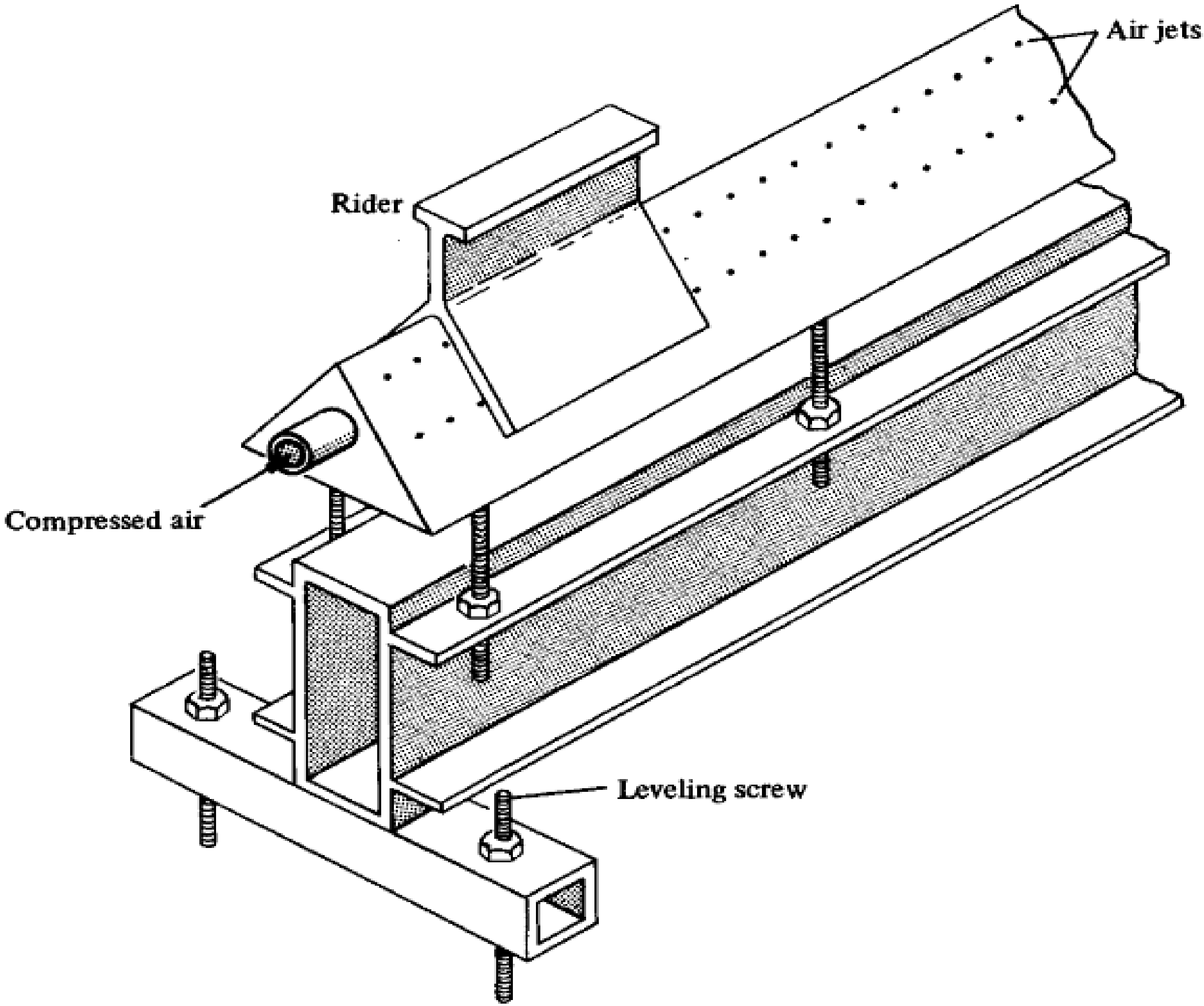
MECHANICS I

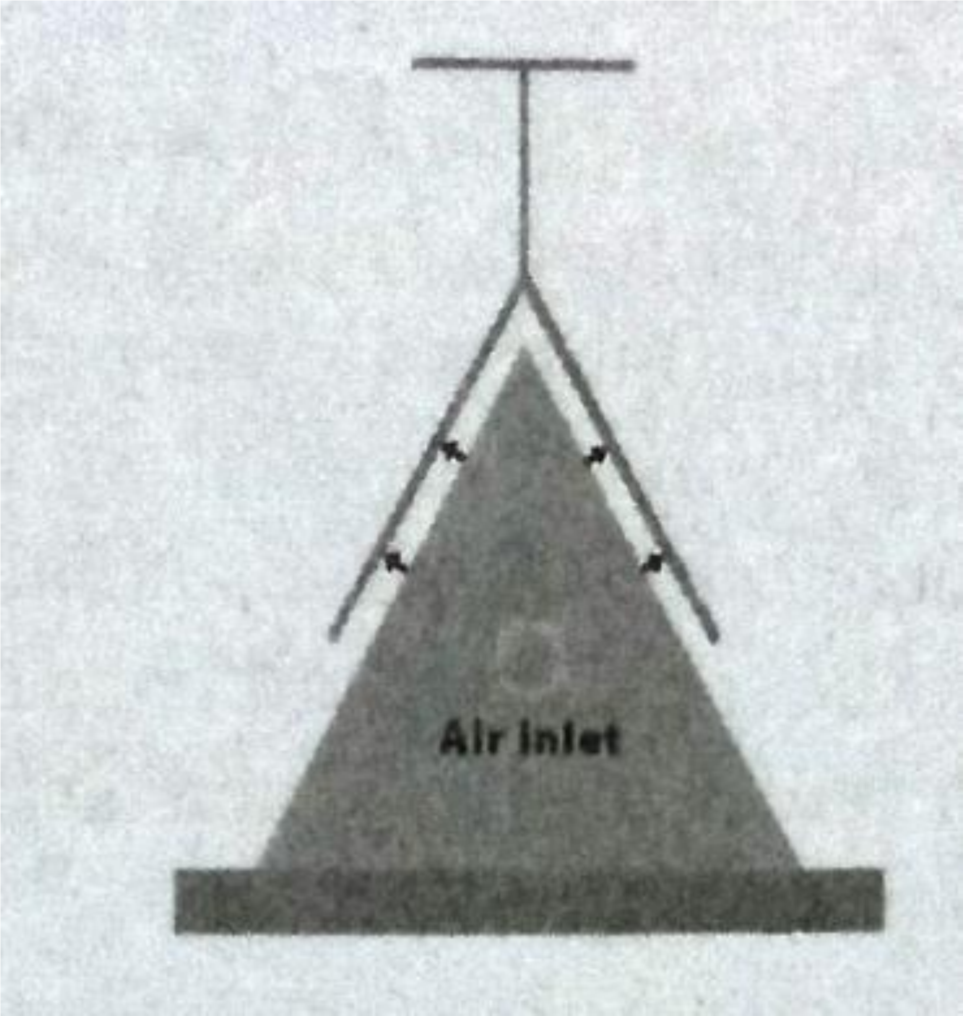
- Newton’s First Law, Second Law and Third Law – Astronauts in space : Inertial systems and fictitious forces – Standards and units – Some applications of Newton’s laws – The astronauts’ tug of war, Freight train, Constraints, Block on string, The whirling block, The conical pendulum – The everyday forces of physics – Gravity and Weight; Gravitational force of a sphere; Turtle in an elevator; Gravitational field – Electrostatic force – Contact forces; Block and string; Dangling rope; Whirling rope; Pulleys; Tension and Atomic forces; Normal force; Friction; Block and wedge with friction; Viscosity – Linear restoring force; Spring and block : The equation for simple harmonic motion; Spring and gun : Illustration of initial conditions – Dynamics of a system of particles – The Bola – Centre of mass – Drum major’s baton – Centre of mass motion – Conservation of momentum – Spring Gun recoil

- Newton's laws provide a direct introduction to classical mechanics
- there are a number of other approaches. Among these are the formulations of Lagrange and Hamilton, which take energy rather than force as the fundamental concept.
- there are important areas of physics in which Newtonian mechanics fails, relativity and quantum mechanics.

Newton's First Law

- Every body continues it's state of rest or uniform motion until it is compelled by an external motion.
- experiments in mechanics are among the hardest in physics because motion in our everyday surroundings is complicated by forces such as gravity and friction.
- a device known as a *linear air track,* which approximates ideal conditions, but only in one dimension.

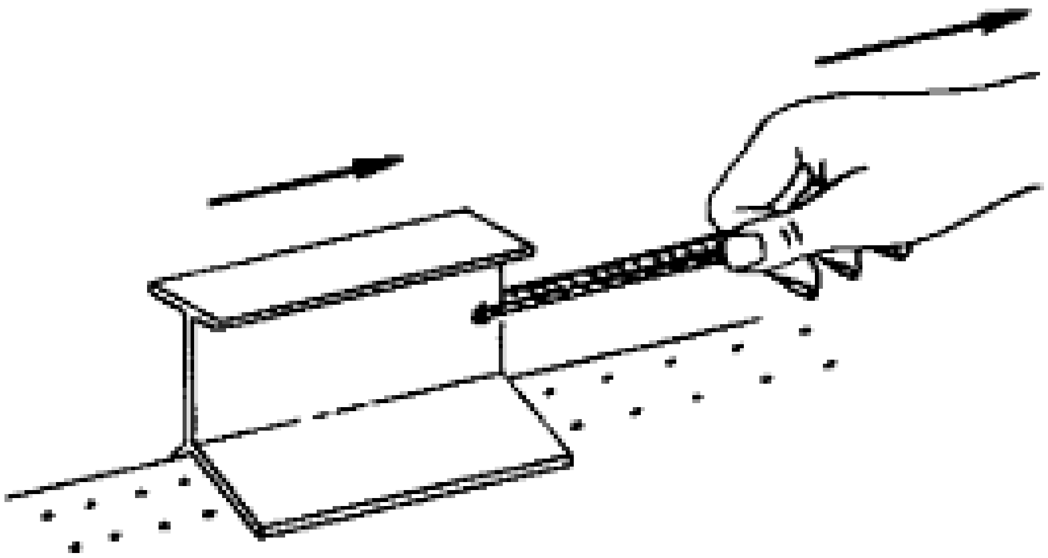

Air jets
Rider
Compressed air
Leveling screw


Air inlet

- In a coordinate system a system moving uniformly with respect to the track, with constant velocity. Such a coordinate system is called an *inertial system*.
- Accelerated = *Non – inertial*

Newton's Second Law

- **The rate of change of momentum on a body is directly proportional to the force acting on it and the change of momentum takes place in the direction of the force.**
- when air track is no longer isolated.
- Suppose that we pull the rider with a rubber band.
- If we move our hand ahead of the rider so that the rubber band is always stretched to the same standard length, we find that the rider moves in a wonderfully simple way; its velocity increases uniformly with time. The rider moves with constant acceleration.



- suppose that we try the same experiment with a different rider, perhaps one a good deal larger than the first.
- same rubber band stretched to the standard length produces a constant acceleration, but the acceleration is different from that in the first case.
- Depends on some property of the object, which we called *mass*.
- **mass is a measure of the resistance of bodies to a change in motion.**

- As mass increases, the acceleration is found to be decreasing for the same pulling. Ma = constant
- stretched rubber band as "applying a force”
- When we apply the force, the test mass accelerates at some rate, a. If we apply two standard stretched rubber bands, side by side, we find that the mass accelerates at the rate 2a, and if we apply them in opposite directions, the acceleration is zero.
- force scale by defining the unit force as the force which produces unit acceleration when applied to the unit mass.

- the acceleration produced by force F acting on mass m is $a = F/m$ or, in a more familiar order, $F = ma$.
- force is a vector
- Forces obey the *principle of superposition*
- The acceleration produced by several forces acting on a body is equal to the vector sum of the accelerations produced by each of the forces acting separately.

$$\begin{aligned}\mathbf{F} &= \Sigma \mathbf{F}_i \\ &= \Sigma m \mathbf{a}_i \\ &= m \Sigma \mathbf{a}_i \\ &= m \mathbf{a}\end{aligned}$$

or

$$\mathbf{F} = m\mathbf{a}.$$

Newton's Third Law

- **if body *b* exerts force F_a on body a, then there must be a force F_b acting on body *b*, due to body *a*, such that**

$$\mathbf{F_b = -F_a}$$

- the third law leads directly to the powerful law of conservation of momentum.

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