Essential Physics Formulas: Grade 7

A concise school reference guide

Motion, density, forces, pressure, work, power and energy

1. SI units

Basic and commonly used derived units:

$$[l] = \mathrm{m}, \qquad [t] = \mathrm{s}, \qquad [m] = \mathrm{kg}.$$

$$[v] = \frac{\mathrm{m}}{\mathrm{s}}, \qquad [F] = \mathrm{N}, \qquad [p] = \mathrm{Pa}.$$

$$[A] = \mathrm{J}, \qquad [P] = \mathrm{W}.$$

Speed conversion:

$$1\,\frac{\mathrm{m}}{\mathrm{s}} = 3.6\,\frac{\mathrm{km}}{\mathrm{h}}.$$

2. Uniform motion

Speed:

$$v = \frac{s}{t}.$$

Distance:

$$s = vt.$$

Time:

$$t = \frac{s}{v}.$$

Average speed over the entire journey:

$$v_{\text{avg}} = \frac{s_{\text{total}}}{t_{\text{total}}}.$$

Important

Average speed is usually not equal to the arithmetic mean of the individual speeds.

3. Density

Density:

$$\rho = \frac{m}{V}.$$

Mass:

$$m = \rho V.$$

Volume:

$$V = \frac{m}{\rho}.$$

SI unit of density:

$$[\rho] = \frac{\mathrm{kg}}{\mathrm{m}^3}.$$

Useful conversion:

$$1\,\frac{\mathrm{g}}{\mathrm{cm}^3} = 1000\,\frac{\mathrm{kg}}{\mathrm{m}^3}.$$

4. Gravitational force

The gravitational force acting on a body is:

$$F_g = mg.$$

Here m is the mass of the body and g is the acceleration due to gravity.
In school problems, we usually use:

$$g \approx 9.8\,\frac{\mathrm{N}}{\mathrm{kg}}$$

or approximately:

$$g \approx 10\,\frac{\mathrm{N}}{\mathrm{kg}}.$$

5. Elastic force

When a spring is deformed, an elastic restoring force acts in the direction opposite to the deformation.
Let

$$x = l - l_0,$$

where l_0 is the natural length of the spring and l is its current length.
Hooke's law for the x-component of the elastic force is:

$$F_{\mathrm{el},x} = -kx.$$

The minus sign shows that the elastic force is directed opposite to the displacement from equilibrium.
The magnitude of the elastic force is:

$$F_{\mathrm{el}} = k|x|.$$

Here k is the spring constant:

$$[k] = \frac{\mathrm{N}}{\mathrm{m}}.$$

6. Resultant force

If two forces act in the same direction:

$$F_{\mathrm{res}} = F_1 + F_2.$$

If two forces act in opposite directions:

$$F_{\mathrm{res}} = |F_1 - F_2|.$$

For a body in equilibrium:

$$F_{\mathrm{res}} = 0.$$

7. Pressure of a solid

Pressure:

$$p = \frac{F}{S}.$$

Force:

$$F = pS.$$

Area:

$$S = \frac{F}{p}.$$

The SI unit of pressure is the pascal:

$$1\ \mathrm{Pa} = 1\ \frac{\mathrm{N}}{\mathrm{m}^2}.$$

For the same force, a smaller contact area produces a greater pressure.

8. Pressure in a liquid

The pressure caused by a liquid column at depth h is:

$$p = \rho g h.$$

Here ρ is the density of the liquid.
The total pressure at depth h is:

$$p_{\mathrm{total}} = p_{\mathrm{atm}} + \rho g h.$$

At the same depth in a stationary homogeneous liquid, the pressure is the same.

9. Hydraulic machine

According to Pascal's principle:

$$\frac{F_1}{S_1} = \frac{F_2}{S_2}.$$

Therefore:

$$F_2 = F_1 \frac{S_2}{S_1}.$$

The larger the area of the second piston, the greater the mechanical advantage in force.
A gain in force is accompanied by a loss in displacement.

10. Buoyant force

The buoyant force is:

$$F_A = \rho_{\text{liq}} g V_{\text{sub}}.$$

Here ρ_{liq} is the density of the liquid and V_{sub} is the submerged volume of the body.
If

$$F_A > mg,$$

the body accelerates upward.
If

$$F_A = mg,$$

the body is in equilibrium.
If

$$F_A < mg,$$

the body accelerates downward.
For a floating body:

$$\rho_{\text{liq}} g V_{\text{sub}} = mg.$$

11. Mechanical work

If the force is directed along the displacement:

$$A = Fs.$$

In the general case, if the angle between the force and the displacement is α:

$$A = Fs\cos\alpha.$$

If there is no displacement, the work done by the force is zero.
If the force is perpendicular to the displacement:

$$A = 0.$$

The SI unit of work is the joule:

$$[A] = \text{J}.$$

12. Power

Power shows how much work is done per unit time:

$$P = \frac{A}{t}.$$

Therefore:

$$A = Pt.$$

For uniform motion in the direction of the force:

$$P = Fv.$$

The SI unit of power is the watt:

$$[P] = \text{W}.$$

13. Efficiency

Efficiency is:

$$\eta = \frac{A_{\text{useful}}}{A_{\text{input}}} \cdot 100\%.$$

For a real machine:

$$\eta < 100\%.$$

Some of the input energy is inevitably converted into internal energy or transferred through other non-useful processes.

14. Lever and moment of force

The moment of a force is:

$$M = Fl,$$

where l is the lever arm, that is, the shortest distance from the axis of rotation to the line of action of the force.
For a lever in equilibrium:

$$F_1 l_1 = F_2 l_2.$$

15. Potential energy

The gravitational potential energy of a body at height h is:

$$E_p = mgh.$$

The elastic potential energy of a deformed spring is:

$$E_{\text{el}} = \frac{kx^2}{2},$$

where

$$x = l - l_0.$$

The SI unit of energy is the joule:

$$[E] = \text{J}.$$

16. Kinetic energy

The kinetic energy of a moving body is:

$$E_k = \frac{mv^2}{2}.$$

Kinetic energy depends on the mass of the body and on the square of its speed. If the body is at rest:

$$v = 0 \quad \Longrightarrow \quad E_k = 0.$$

17. Mechanical energy and its conservation

The mechanical energy of a body or system is the sum of its kinetic and potential energies:

$$E_{\text{mech}} = E_k + E_p.$$

If friction and other energy losses can be neglected, mechanical energy is conserved:

$$E_{\text{mech}} = \text{const}.$$

Therefore, for two states of the system:

$$E_{k1} + E_{p1} = E_{k2} + E_{p2}.$$

Energy can be transformed from kinetic energy into potential energy and back again, while their total remains constant.

Problem-solving algorithm

1. Write down the given quantities.
2. Convert all quantities to SI units.
3. Determine which physical law or formula should be used.
4. Rearrange the formula to isolate the unknown quantity.
5. Substitute the numerical values together with their units.
6. Perform the calculation and write down the answer.
7. Check whether the result is physically reasonable.

This reference sheet is intended for quick review. Before using a formula, check the conditions under which it applies and the units of all quantities.