

An airplane requires 20 s and 400 m of runway to become airborne, starting from rest. What is its velocity when it leaves the ground? Please show how to solve.

**Solution.**

$$s = 400\text{m}, t = 20\text{s}, v_i = 0;$$

$$v_f = ?$$

A displacement of the airplane, which it moves with acceleration:

$$s = v_i t + \frac{at^2}{2},$$

$s$  - the displacement of the airplane – runway;

$v_i$  - initial velocity of the airplane;

$a$  - the acceleration of the airplane;

$t$  – time.

$v_i = 0$ , because the airplane starting from rest, therefore:

$$s = \frac{at^2}{2}.$$

A velocity of the airplane, which it moves with acceleration:

$$v_f = v_i + at,$$

$v_f$  – the final velocity of the airplane.

$$v_f = at.$$

$$a = \frac{v_f}{t}.$$

We substitute the expression for the acceleration in the equation for the displacement:

$$s = \frac{v_f t^2}{2t} = \frac{v_f t}{2},$$

$$s = \frac{v_f t}{2}.$$

The final velocity of the airplane when it leaves the ground:

$$v_f = \frac{2s}{t}.$$

$$v_f = \frac{2 \cdot 400 \text{ m}}{20 \text{ s}} = 40 \frac{\text{m}}{\text{s}}.$$

**Answer:** The velocity of the airplane when it leaves the ground is  $v_f = 40 \frac{m}{s}$ .