

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 $v_f = 40 \frac{m}{s}$.