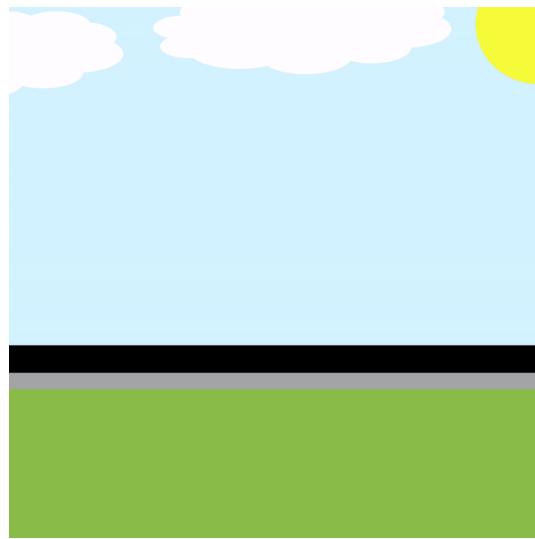


# Passenger Plane Take-Off



The pilot of a passenger plane brings the engines to full take-off power before releasing the brakes as the aircraft is standing still on the runway. The jet thrust remains constant, and the aircraft has a near-constant acceleration of  $0.4g$ . If the take-off speed is  $v_1 = 216 \text{ km/h}$ , what is the distance  $s_1$  in meters the plane needs to take off?

Neglect air resistance and take  $g = 10 \text{ m/s}^2$ .

*Using known expressions (for constant acceleration):*

$$a = \frac{dv}{dt} \Rightarrow dv = adt \quad (1)$$

$$\int_{v_0}^{v(t)} dv = a \int_0^t dt \quad (2)$$

$$v(t) = at + v_0 \quad (3)$$

$$v = \frac{ds}{dt} \Rightarrow ds = vdt = (v_0 + at)dt \quad (4)$$

$$\int_{s_0}^{s(t)} ds = \int_0^t (v_0 + at) dt \quad (5)$$

$$s(t) = \frac{1}{2}at^2 + v_0 t + s_0 \quad (6)$$

*Given quantities:*

Gravitational acceleration:  $g = 10 \text{ m/s}^2$

Acceleration:  $a = 0.4g = 0.4 \cdot 10 = 4 \text{ m/s}^2$

Initial velocity:  $v_0 = 0 \text{ m/s}$

Final velocity:  $v_1 = 216 \text{ km/h} \approx 60 \text{ m/s}$

*Solution:*

In the case of this exercise,  $s_0$  and  $v_0$  are equal to zero, resulting in:

$$v(t) = at \quad (7)$$

$$s(t) = \frac{1}{2}at^2 \quad (8)$$

Filling in  $v_1 = 60 \text{ m/s}$  and  $a = 4 \text{ m/s}^2$  in Equation (7) results in:

$$v(t_1) = at_1 = v_1 \Rightarrow 60 = 4 \cdot t_1 \Rightarrow t_1 = 15 \text{ s} \quad (9)$$

Inserting  $t_1 = 15 \text{ s}$  in Equation (8) results in the final answer  $s_1$ :

$$s_1 = s(15) = \frac{1}{2} \cdot 4 \cdot 15^2 = 450 \text{ m} \quad (10)$$