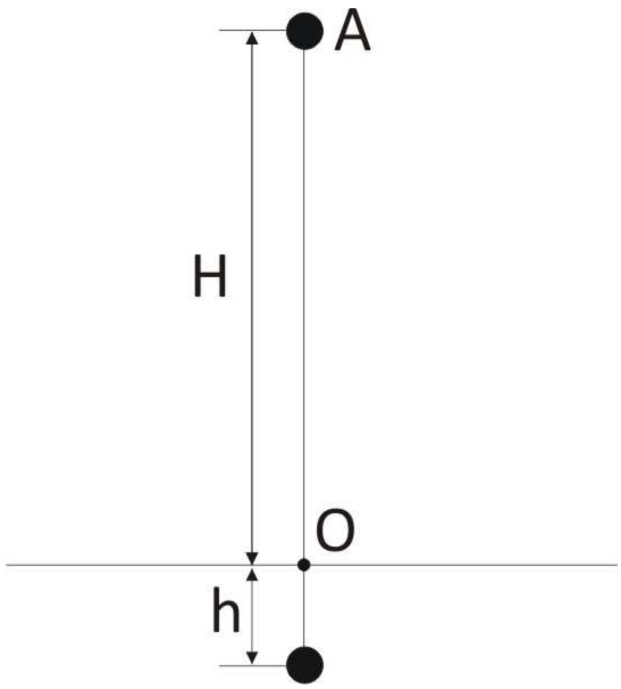
A stone weighing 3 kg falls from the top of a tower 100 meters high and buries itself 2 meters deep in the sand. The time of penetration is?

Solution.

$$m = 3kg, H = 100m, h = 2m, g = 9.8\frac{m}{s^2};$$

$$\Delta t - ?$$



The change of the potential energy of the stone is equal the work of the resistance force of sand:

$$\Delta W_p = Fh;$$

$$\Delta W_p = mg(H + h);$$

$$mg(H + h) = Fh.$$

The change of the momentum of the stone is equal product of the resistance force at the time:

$$\Delta p = F\Delta t;$$

$$\Delta p = p_2 - p_1;$$

$$p_1 = mv_1;$$

$v_1 = 0$ - the stone is at rest.

$$p_1 = 0.$$

$$p_2 = mv_2;$$

$$\Delta p = mv_2 - 0 = mv_2.$$

$$\begin{cases} mv_2 = F\Delta t; \\ mg(H+h) = Fh. \end{cases}$$

Divide first equation by second equation:

$$\frac{v_2}{H+h} = \frac{\Delta t}{h};$$

The time of penetration:

$$\Delta t = \frac{hv_2}{H+h}.$$

v_2 we will find from the law of conservation of energy.

The kinetic energy of the stone at the point **O** is equal the potential energy of it at the point **A**:

$$W_k = W_p;$$

$$\frac{mv_2^2}{2} = mgH;$$

$$v_2 = \sqrt{2gH}.$$

$$\Delta t = \frac{h\sqrt{2gH}}{H+h}.$$

$$\Delta t = \frac{2 \cdot \sqrt{2 \cdot 9.8 \cdot 100}}{100+2} = 0.868(s).$$

Answer: The time of penetration is $\Delta t = 0.868s$.